NOLOGY DEPARTMENT

Power Generation

INCLUDING Power Plant ENGINEERING ESTABLISHED 1896

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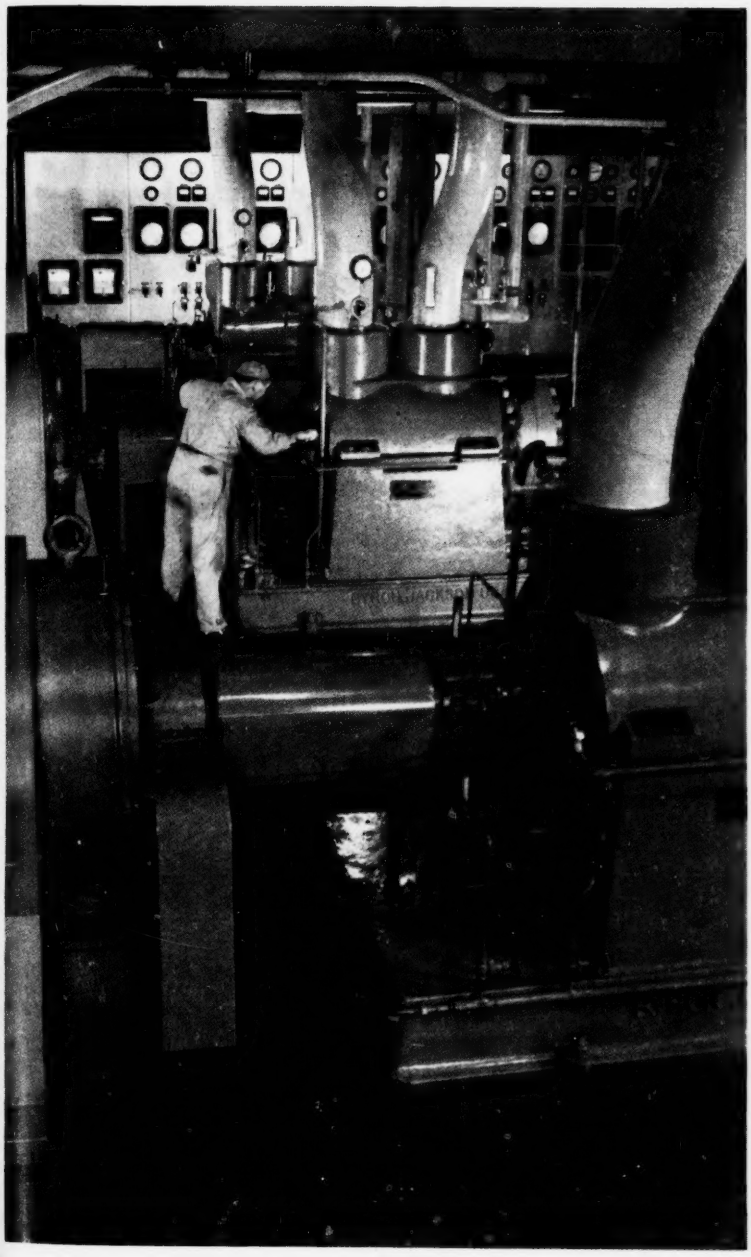

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COVER: THREE MOTOR-DRIVEN BOILER FEED PUMPS OF 500,000 LB PER HR CAPACITY EACH, AT 1840 PSIG DISCHARGE PRESSURE AND 440 PSI SUCTION PRESSURE EACH DRIVEN BY 1400-HP, 3600-RPM MOTOR; INSTALLED TO SERVE NEW UNIT NO. 7 AT SPRINGDALE POWER STATION, WEST PENN POWER CO.

The Magazine That Helps Men Responsible for Generation of Steam, Electricity and All Other Forms of Power Supply

R v.52 Jan.-June 1948

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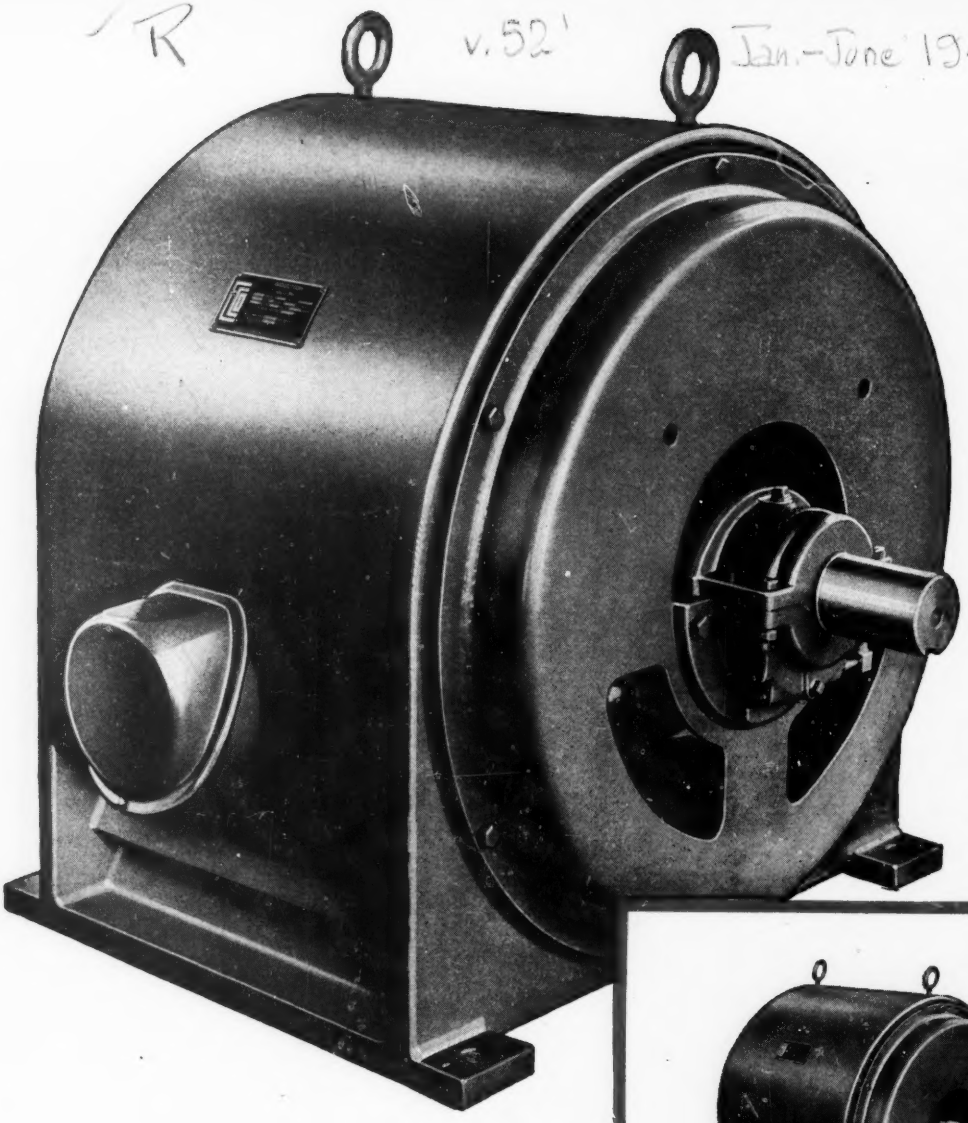

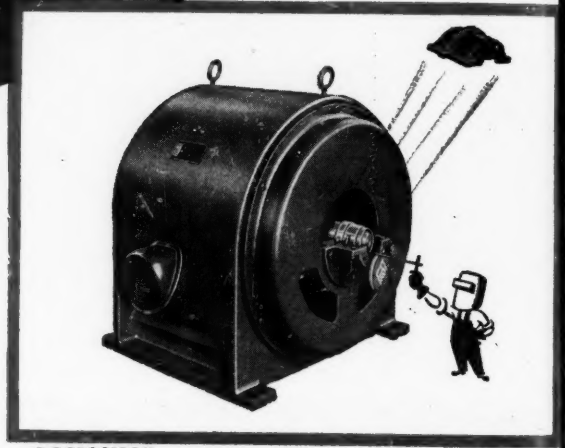

ACCESSIBLE—take off the bearing cap—and there's your bearing! You can lift off the top half, then take the weight of the rotor off the bottom half and roll that out too.

Elliott

Tech

FABRIS

"...threw away the book"

...and came out with a better motor!

TRADITION says cast iron for motor enclosures—but Elliott advanced welding technique says STEEL—because of its rigidity, its tough, crack-proof strength, its workability, its lightness. This decision, once made, enabled Elliott designers, to plunge with enthusiasm into the job of developing a new standardized line of motors. Unhampered by the ball-and-chain of outmoded material limitations, they were able to incorporate ideas which had never before appeared in large motors. . . . Split sleeve bearings made exceptionally easy to get at. . . . Greater uniformity in air gap, assured by jigged-up precision machining and drilling of stator end plates and bearing brackets, and integral rigid stator assembly. . . . Positive, **directed** ventilation without recirculation. . . . Streamlined design, beautiful in appearance, saving 25% in space over former designs. . . . A 30% weight saving in the bearing bracket alone — 10% saving over the entire motor. These are just a few of many features that mean quieter, smoother performance and simplified maintenance.

150 to 1000 hp; four to fourteen poles; drip-proof, splash-proof, force-ventilated, pipe or base-ventilated. Bulletin on request.

ELLIOTT COMPANY
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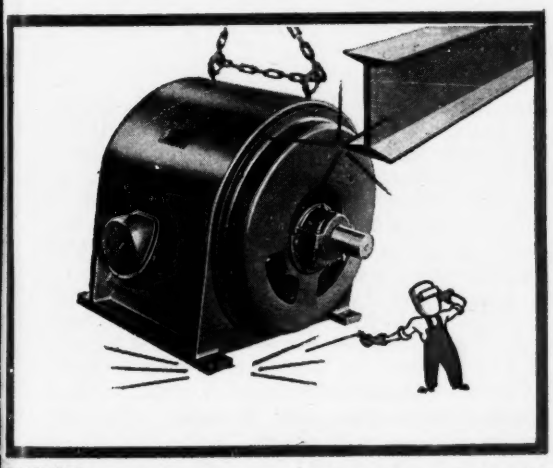
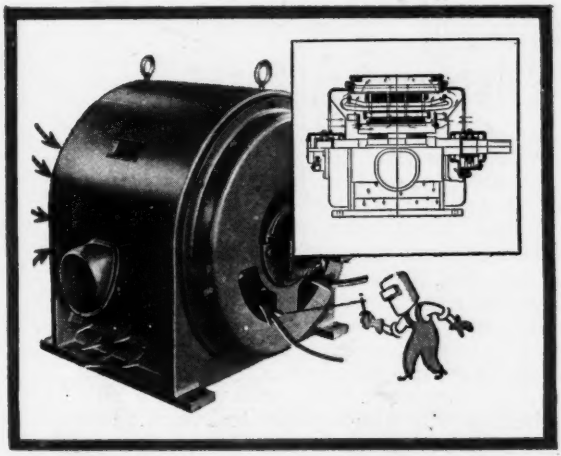


TOUGH — no fear of cracking a bearing bracket or breaking off a foot, with this all-steel motor. Rigid too, with the built-up, unyielding stiffness of fabricated steel.



COOL-RUNNING — because of **directed** air-flow, driven by radial fan and guided around and through rotor and stator, then out, taking heat with it. No recirculation.

L-776

...RISTEEL Motors

FACTS YOU SHOULD KNOW

About the 1948 STEEL VALVE Outlook

AN ANNUAL REPORT
TO STEEL VALVE USERS

A year before the war started, steel valves became difficult to obtain. One of the most critical wartime industrial commodities, steel valves have been required in large quantities for postwar construction programs.

What is the situation now? How about prices, deliveries, new design developments? These are our observations . . .

LITTLE INCREASE IN VALVE PRICES

The steel valve industry has done its share in keeping prices down. Edward selling prices, for example, are now on the average only about 10 per cent above those in effect before Pearl Harbor. It is hard to think of any durable goods industry which today serves the buyer on such a favorable price-value basis. Steel valves are real bargains—they don't hold up construction programs because of high cost.

DELIVERIES IMPROVING, BUT—

Deliveries of Edward valves, on the whole, are considerably better than they were a year ago.

Most small forged steel valves are obtainable from stock or upon short delivery.

Larger steel valves, however, continue to require fairly long lead times and undoubtedly that will be the case for all of 1948. Expansion commitments of the steam generating, petroleum and process industries are such that there is little possibility that deliveries can be shortened very much on steel valves in sizes above six inches, particularly in the higher pressure and temperature series, until well into 1949.

It is therefore still wise to place steel valve orders as far in advance as possible.

ONE WAY TO CUT INVENTORIES

Most businesses are greatly concerned about mounting inventories. Among the several causes for increased inventories, we think, is the buying of "specials." Take the case of valves: standard valves with a high degree of interchangeability require the stocking of very few repair parts; non-standard valves with trick attachments mean extra inventories for repairs and delays in receiving emergency replacements.

The steel valve industry today has a complete line of standard valves suitable for fully 99 out of 100 installations. For better deliveries, lower cost, known performance and smaller inventories, stick to the standard.

NEW DESIGNS FOR NEW SERVICES

There is, as we said, a standard valve for virtually every service today. That is another way of saying that the valve industry has kept up with the technological advancements of the power, petroleum, and the varied process industries.

For instance, take Edward. Each new Edward catalog has listed basically new valves for higher pressures and temperatures. During the past year, Edward continued to improve its original designs for pressure sealed valve bonnets, welded body-bonnet valve joints, closing mechanisms, seating systems, etc.

Not all the advancement is confined to specific valve designs, either. For instance, the continuing research of the Edward laboratories into the characteristics of flow and the economics of pressure loss has not only led to the development of the Edward Equalizer for increasing flow through valves, but also has been widely heralded as a contribution to the knowledge of the fundamentals of flow through pipes. Edward engineers have shared their findings and experience with others interested in the same problem.

MEN AT WORK

As a unit of the Rockwell Manufacturing Company, Edward has access to the combined facilities of the other Rockwell plants in all parts of the United States.

This permits more economical manufacturing, an even greater research program, fewer headaches in obtaining materials and equipment which continue in short supply—in other words, more men and minds at work on a common objective.

And right here at the Edward plant, employment is at an all-time high. Almost all the experienced Edward personnel that left for war service came back, and many new men and women have been trained. In 1947 expenditures for Edward production facilities also reached an all-time high, exceeding even our big wartime expansion programs.

Consequently we sincerely feel that we are in the best position ever to take care of your steel valve requirements in pressures from 150 psi up, in sizes from ⅛ in. to 16 in., for all temperatures, and for boiler room, petroleum, industrial, marine or technological service.

W. F. Crawford
President

Edward Valves, Inc.

SUBSIDIARY OF ROCKWELL MANUFACTURING CO.
EAST CHICAGO, INDIANA

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Published Monthly by
TECHNICAL PUBLISHING CO
53 W. JACKSON BLVD.
CHICAGO 4, ILL.

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WASHINGON, D. C., OFFICE
Business Press News Bureau
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Subscription Information—Published Monthly. Prices: United States and Possessions one year $10.00, Canada one year $11.00. Other countries one year $12.00. Single copies $1.00. Changes of address should give both old and new address and reach us by 15th of month to be effective with following month's issues. The Annual Index is furnished as a part of the December issue.

Power Generation

January, 1948

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Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.

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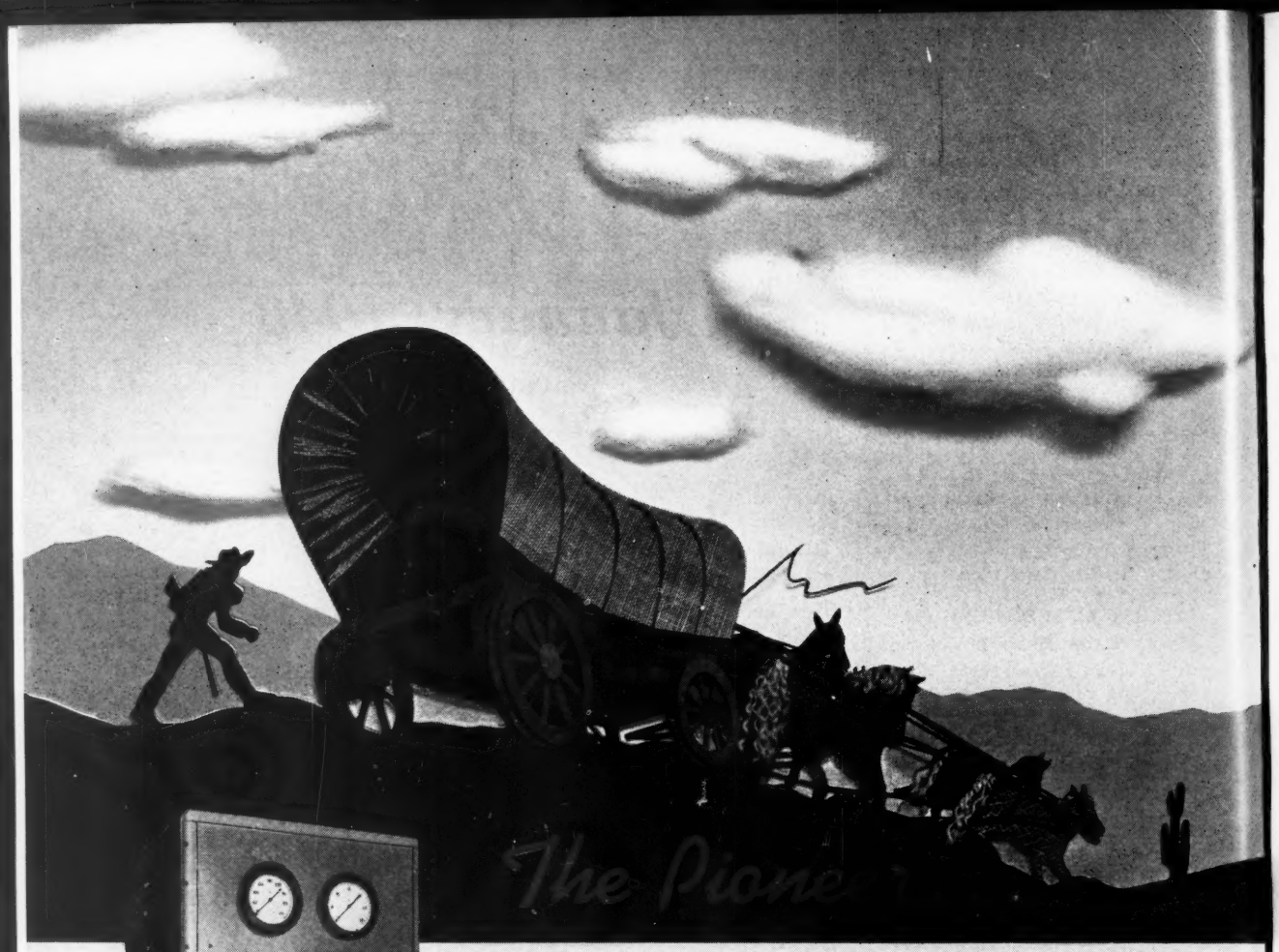
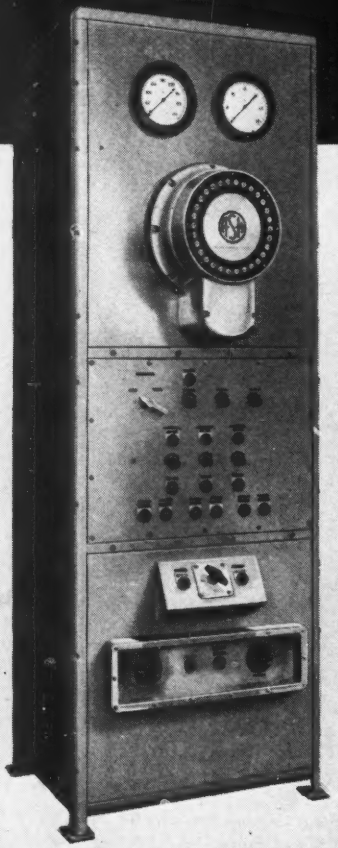
Entered as second class matter September 8, 1932 (original entry May 1, 1908), at the Post Office, Chicago, Illinois, under act of March 3, 1879.





AUTOMATIC DUST HANDLING SYSTEM

...HYDROVAC

Our trek into the unexplored unknown of automatic dust handling began over ten years ago. We sought the ultimate . . . a system that seemingly "thinks for itself" . . . one with the uncanny reliability that is foolproof. . . . Success, in rewarding our pioneering quest, has uncovered a surprise economy bonanza because "time has more effect on wear than tonnage." Continuous, top-speed operation of automatic dust removal reduces all maintenance, particularly pipeline. . . . The Automatic Sequence Head (pictured at left, patents pending) is, as its name implies, the head or brain controlling this Hydrovac System. It opens and closes dust valves, skips over boilers off the line, warns of unusual conditions, tells what is happening all the time, and closes the system when all dust is removed. . . . Get the complete story from our representative, then you'll agree it's more than a sound investment. . . . The Allen-Sherman-Hoff Company, 233 S. 15th Street, Philadelphia 2, Pa.

AUTOMATIC **SEQUENCE** **HYDROVAC**
AUTOMATIC **SEQUENCE** **HEAD**
ALLEN **SHERMAN** **HOFF**

ENGINEERS' PREVIEW

Announcing a New Name for an Old Friend

WE HOPE YOU like the new cover on this issue. The name is changed from the old familiar *Power Plant Engineering* to *Power Generation* in line with our object of providing a more specialized and helpful service to the fast-expanding field of power generation and distribution.

The power plant field, like many other phases of industry, has been undergoing a constant process of evolution.

The vastly increasing importance of power supply to our many factories, mines and service establishments—coupled with marked technical advances in the steam turbine, higher operating pressures and temperatures, the mercury cycle, the gas turbine, and atomic energy—all turn the spotlight on power generation as a highly-developed and complex science of its own.

The decision to give 50-year-old *Power Plant Engineering* the new title of *Power Generation,* beginning with this issue, is part of our program to provide a more concentrated editorial and product information service to a larger but more concentrated group of men with kindred interests and problems in steam and power generation, and all other phases of power supply, in both utility and industrial power plants.

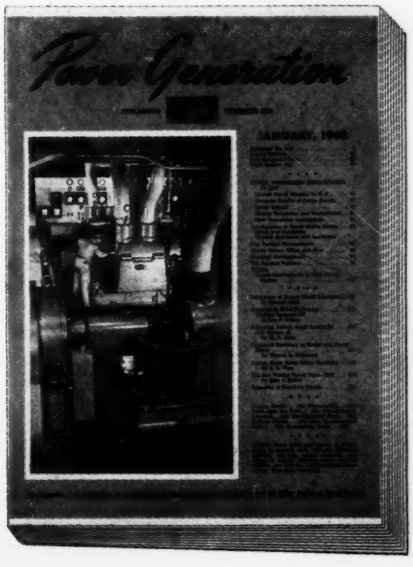
Its improved editorial pattern will include such important topics as:

1. New Developments in Power Plant Equipment, Descriptions of New and Outstanding Power Plants
2. All Problems of Power Plant Construction, Operation and Maintenance
3. Steam Generation in all types of power plants —steam generating units, fuels, combustion, firing methods, feedwater and air supply
4. Steam and Gas Turbines—condensers and other auxiliaries
5. Hydro-electric Power Plant Equipment — hydraulic turbines, water control devices, etc.
6. Diesel Engines, Gas Engines and Auxiliaries
7. Pumps and Air Compressors, auxiliaries and related problems
8. Water Supply and Treatment
9. Fuel Handling and Storage
10. Piping, Valves and Specialties
11. Instruments and Controls
12. Steam, water, compressed air, and other power plant services for processes and heating, also refrigeration and air conditioning services.
13. Electrical Problems of the Power Plant—generators and auxiliaries, switchgear, problems of supplying electricity to industry
14. Developments in thermodynamics, heat transfer, electronics and other fundamental subjects
15. The Atomics Section, which proved so popular in *Power Plant Engineering,* will continue as before in *Power Generation*

These and all other subjects related to the interests and duties of the Power Engineer will continue to receive the same authoritative treatment by the country's leading engineers in *Power Generation* as they have in *Power Plant Engineering.*

In *Power Generation,* too, you will find carried on as usual, the familiar features of: The Practical Engineer, devoted to practical operating problems; Engineers' Preview; What Leaders Say; and the very popular and practical sections on Letters and Comments and Questions and Answers.

In short, there will be no change in the magazine except the change of name to *Power Generation.* It is our hope to make the magazine, under the new title, continually more effective in helping power engineers with their everyday problems, and to aid them in preparing for the interesting changes and developments in which they must take part during the next few years.



GERMAN TECHNICAL ADVANCES before and during World War II in the manufacture of synthetic materials from by-products of the high-temperature carbonization of caking bituminous coal are described in a new Bureau of Mines publication. Aside from the manufacture of synthetic liquid fuels and fuel briquettes, coal tar also was highly valuable for the production of plastics, synthetic rubber, explosives, dyes, pharmaceutical preparations, and synthetic drugs. During the war, Germany virtually abandoned the use of coal tar in the making of creosote for wood preservation and refined tars for road construction.

In discussing new or improved tar-plant equipment, the publication describes a continuous tar still of unusual design offering several advantages over batch sills. Some changes in equipment design were necessitated by an increased demand for hard pitch for pitch coke and plastic compounds. Improvements also were effected in pitch-cooling equipment, anthracene recovery equipment, and tar-acid extracting equipment.

Among new or increased uses of pitches and tar oils developed in Germany were electrode coke manufacture, making of special pitch compounds, road tars, carbon black, lubricating oils and greases, hydrogenation of pitch and tar oils, coal briquetting, and roofing and waterproofing compounds.

A copy of the publication, Information Circular 7409, "German High-Temperature Coal-Tar Industry," may be obtained by writing to the Bureau of Mines, Publications Section, 4800 Forbes Street, Pittsburgh 13, Pa.

★ ★ ★

BUILT-UP sections between terminals on Jones barrier terminal strips increase the leakage path and prevent direct shorts from frayed wire ends. Molded of black Durez, the strips have excellent dielectric properties, also improve appearance of the equipment. Terminals and screws are of nickel-plated brass. Three types are available: screw terminals, screw and solder terminals, and screw terminals above panel with solder terminals below. These are supplied with various combinations of screws.

★ ★ ★

FOILCLAD, a new insulated pipe unit for outdoor overhead applications, has recently been announced. This employs copper or aluminum foil, use of which was greatly restricted during the war but now available again. In the Foilclad construction, the pipe as specified is first covered with a loose-fitting asbestos pipe covering of the desired thickness. This insulation is then machine-coated uniformly with high-temperature asphalt and wrapped with asbestos felt, followed by an additional coating of asphalt to a thickness of 1/4 in. or more if desired. Finally, the outside is specially wrapped with a sheet of thin electrolytic copper or pure aluminum, making a perfect bond with the hot asphalt. Furnished for any type of joint, the Foilclad units are delivered to the job in 21-ft lengths, eliminating field work of applying all the above insulating materials. Galvanized iron sleeves, wedge clips, expansion loops, fittings and the like are furnished to make a complete system. Overhead supporting method uses galvanized iron bands for pipe up to 3 1/2 in. and rollers for 4 in. and larger, which suspend pipe independent of insulation.

TUBELESS TIRE, product of over 5 years' research by B. F. Goodrich Co., may soon be available to American motorists. The new tire looks like the regulation casing, is applied to the regular tire rim, requires about normal low-pressure inflation. Described as a "seal-o-matic tubeless tire," it is claimed to be self-sealing against normal cuts and penetration, and to have high heat dissipation.

★ ★ ★

IN ADDITION TO the plastics now being used as a substitute for zinc and copper in zinc etchings and photo-engravings for printing, another material, magnesium, is being used. It is claimed to etch satisfactorily—cuts made from it are reproduced in the *Dow Diamond*—it is only one-fourth the weight of copper, saving weight in handling, storing and on presses; and it work-hardens so that it wears as well as copper and better than zinc.

★ ★ ★

ONE OF THE successful methods for building good will among employees is to show them that you are interested in their welfare. If you have a staff of assistant engineers or watch engineers and firemen working under you, one of the most effective ways your company can foster good feeling is to provide them with help on their income tax problems. This goes, of course, for all employees of your company. It might be a good idea to call management's attention to the new edition of the EMPLOYEE'S 1948 INCOME TAX HANDBOOK, just published by the Industrial Relations Institute, a division of Commodity Research Bureau, Inc. It is a 32-page booklet giving complete detailed instructions for computing an employee's income tax for 1947, whether it is paid on the withholding basis or must be calculated on Form 1040. It sells for 20 cents a copy in lots of 250 or less and special prices are given for larger quantities. Many companies buy these booklets and distribute them free to employees.

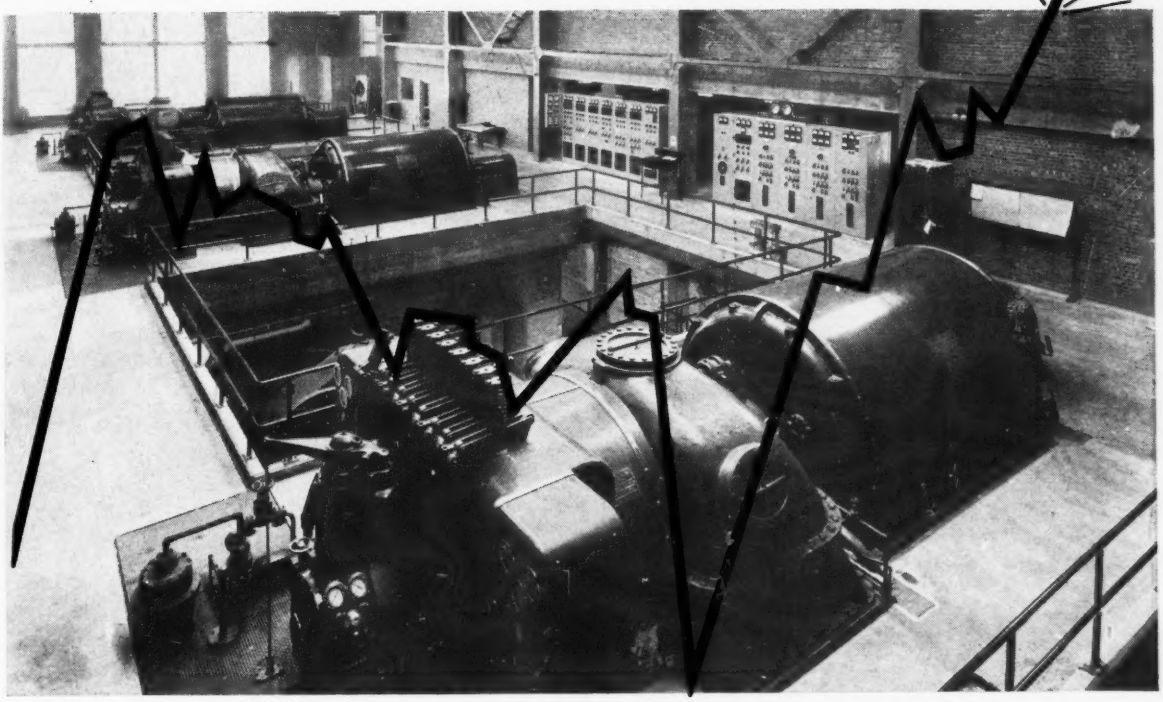
★ ★ ★

GUIDED MISSILE capable of traveling 5000 miles will become a reality within 15 years, predicted Brig. Gen. Donald L. Putt, deputy chief of the engineering division, Air Materiel Command, before the National Safety Congress recently. General Putt's estimate of time required is based on the peacetime research pace, but the Air Force believed that a 5000-mile missile could be completed within 5 years provided there were unlimited funds and resources at its disposal.

★ ★ ★

DETAILS of an industry-wide co-operative effort at Kure Beach near Wilmington, North Carolina, where a great corrosion-testing project is under way, are now given in an illustrated report. The project is to test effects of salt water, salt air and marine organisms upon metal, wood and other materials. This has been studied exhaustively for 12 years and data accumulated are freely exchanged and available to all industry and to government agencies. Maintenance and development costs are shared by The International Nickel Co. and The Dow Chemical Co. The project was developed by F. L. LaQue of International Nickel and is operated under his direction.

ASSURE POWER OUTPUT



...TO MEET RECORD DEMANDS

Keep your turbines *free from sludge and rust* with *Texaco Regal Oils (R & O)*

TODAY'S record demand for power means that turbines must run for longer periods between overhauls. Hence the importance of using oils designed to give *full* protection . . . to prevent sludge, rust and foam—*Texaco Regal Oils* (*R & O*).

Texaco Regal Oils (*R & O*) are the Texaco Regal Oils that have been world-famous for more than 20 years . . . *improved* with inhibitors against rust and oxidation, and specially processed to prevent foaming. They are specifically designed to keep turbine lubricating systems clean, bearing temperatures normal, governor action smooth and responsive.

In new turbines, the rust-inhibiting properties of *Texaco Regal Oils* (*R & O*) are especially important. The inhibitor plates out on the metal and assures a rust-free system right from the start. In addition, *Texaco Regal Oils* (*R & O*) give extra long service life. They meet the turbine oil specifications of all leading turbine manufacturers and of the United States Navy.

Texaco has a complete line of lubricants for turbines and all power plant auxiliaries. Talk to a Texaco Lubrication Engineer. Just call the nearest of the more than 2500 Texaco Distributing Plants in the 48 States, or write: The Texas Company, 135 East 42nd Street, New York 17, N. Y.

TEXACO

TEXACO Regal Oils (R&O)

FOR ALL TURBINES

TUNE IN...TEXACO STAR THEATRE presents the TONY MARTIN SHOW every Wednesday night. • METROPOLITAN OPERA broadcasts every Saturday afternoon.

Public Service (N.J.) *Chooses*

YARWAY

Burlington, N. J., Station of the Public Service Electric and Gas Company. Four boilers at this plant, and two at Public Service's Marion Station are each equipped with the Yarway Unit Tandems. Steam pressure boiler 1350 psi, turbine 1250 psi. Temperature 950° F. Output, each boiler, 350,000 lbs per hour; high pressure turbines, 125,000 KW each.

YARWAY BLOW-OFF VALVES

UNIT TANDEMS

FOR HIGH PRESSURE BLOW-DOWN SERVICE

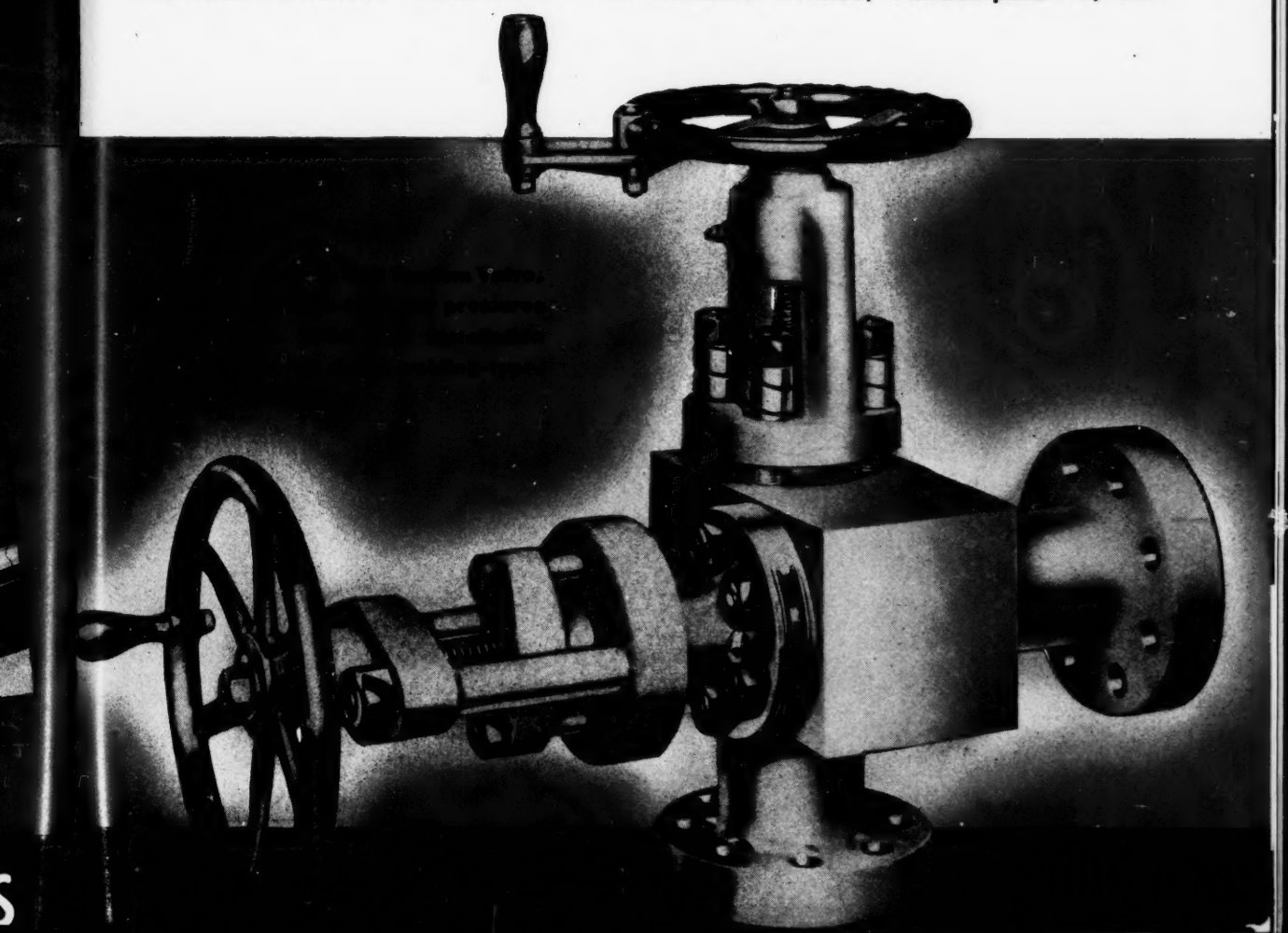
Why has the Public Service Electric and Gas Company of New Jersey, like so many other leading utilities, selected Yarway Unit Tandem Blow-Off Valves for their high pressure boilers? The answer is simple—*proved performance.*

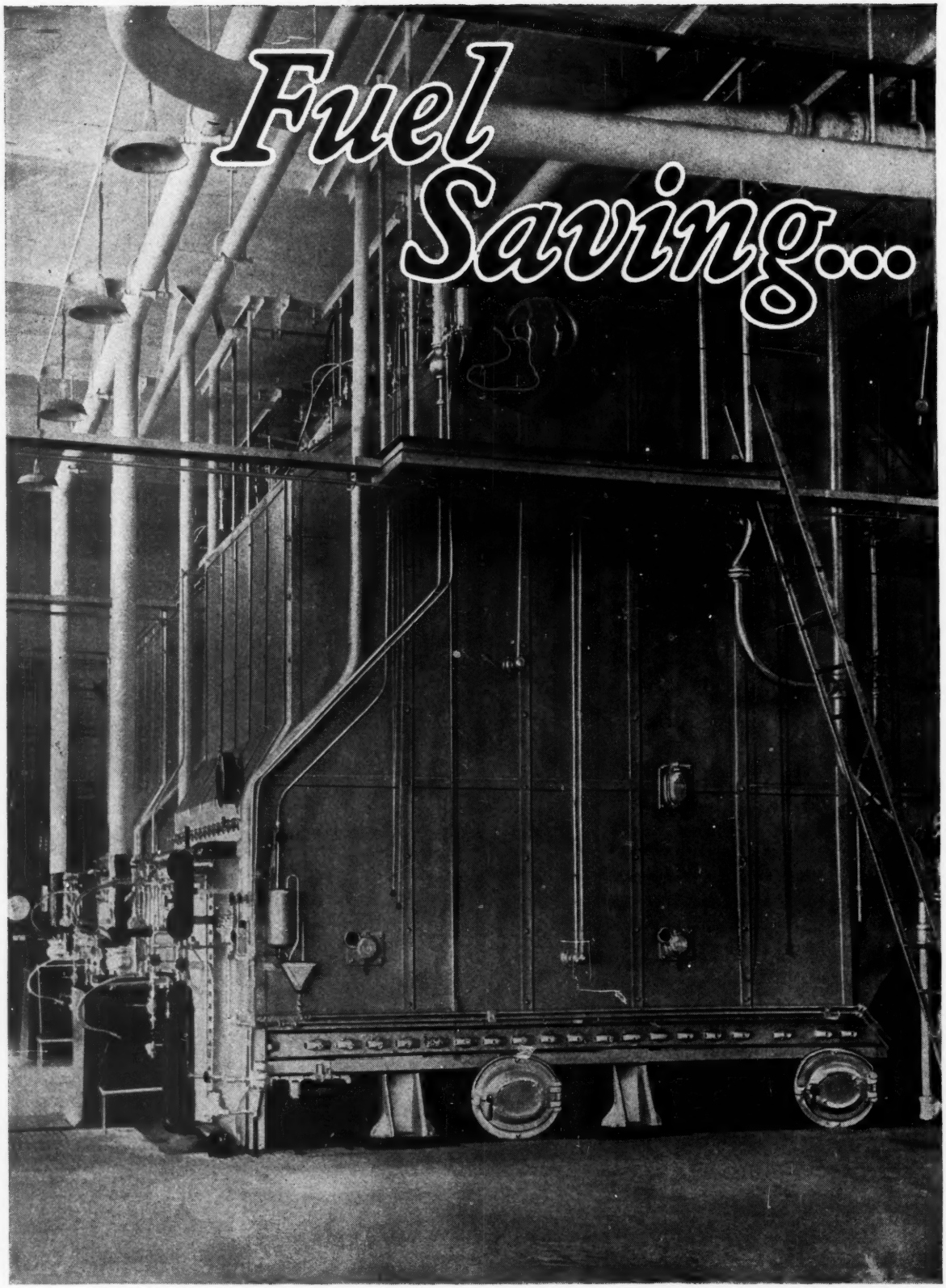
Yarway Unit Tandems have proved themselves unequalled in service throughout all industries on pressures from 400 to 2500 psi. This tandem is a combination of the Yarway Hard-Seat* Valve (next to boiler for blowing) and the famous Yarway Seatless Valve (for sealing)—both contained in a one-piece forged steel body. This rugged construction eliminates the interconnecting flanges, bolts and gaskets required in bolted tandem designs, making a trim, compact unit.

Nearly 40 years of laboratory and field experience concentrated on blow-off valve requirements, makes Yarway a logical source of supply for your next blow-off valves. Write for Catalog B-432 for pressures up to 2500 psi . . . Catalog B-424 for lower pressures.

** Seats furnished either separate or integral.*

YARNALL-WARING COMPANY • 114 Mermaid Avenue, Philadelphia 18, Pa.

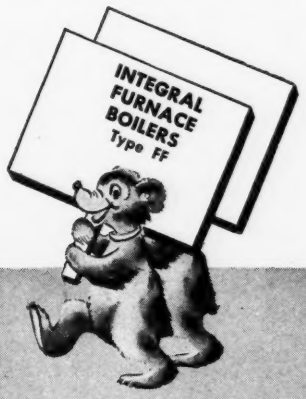




This installation of B&W CUBS* consists of two oil-fired Type FF Integral-Furnace Boilers. Steam Capacity of each is 35,000 lbs. per hr. at 160 psi, 350 F.

25%

with B&W "CUBS"*



How boiler plant modernization is helping to offset rising fuel costs is typically illustrated by the recent experience at a southern asbestos products plant. When *two* new B&W CUBS* replaced *six* old hrt units, a fuel saving of 20 to 25 per cent was immediately realized, along with substantially higher steam generating capacity.

Plant expansion shortly after the CUBS* went into service greatly increased steam demands. "We would have been unable to take care of the situation with the old units", reports the Company. "As it was, the new boilers ran away with the load. All in all, we are very much pleased with their performance, and feel that they are *one of the best investments we ever made*".

Any industrial plant requiring boilers of 10,000 to 50,000 lb. per hr. steam capacity can have the cost-saving benefits that are "wrapped up" in all B&W CUBS*. Three *different types* are available, each having distinctive features that make it the best choice for a wide variety of operating conditions. A B&W engineer will be glad to explain fully why they are such a good buy.

*Complete Unit BoilerS

Each as much a package boiler as any unit of its capacity can be.

G-357T

FOR POWER PLANTS — B&W, Open-Pass, Radiant, Integral-Furnace, Cross-Drum, Stirling and Waste-Heat Stationary Boilers . . . Air Heaters . . . Economizers . . . Superheaters . . . Water-Cooled Furnaces . . . Oil, Gas & Multi-fuel Burners . . . Chain-Grate Stokers . . . Stacks and Breechings . . . Seamless & Welded Tubes . . . Refractories . . . Chemical Recovery Units . . . Alloy Castings.

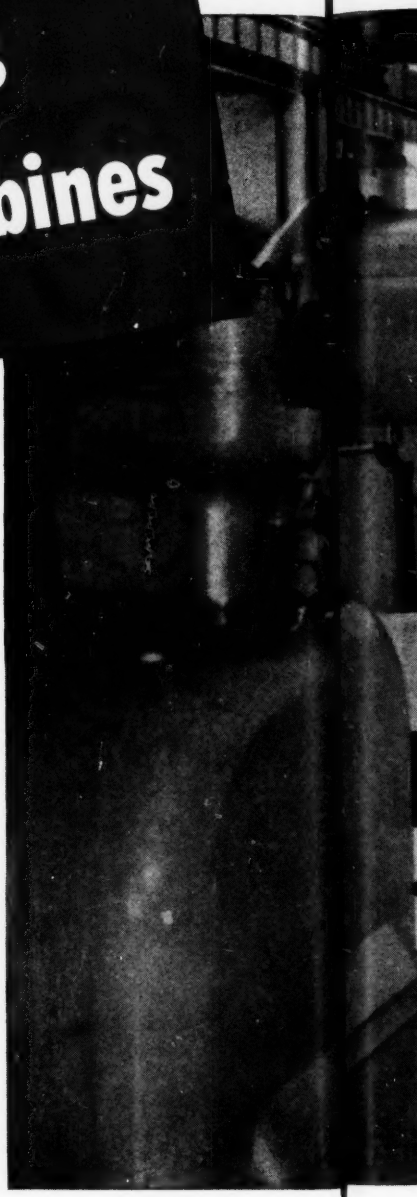
★ ★ ★

OTHER B&W PRODUCTS — Marine Boilers . . . Pressure Vessels . . . Process Equipment.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
GENERAL OFFICES: 85 LIBERTY ST., NEW YORK 6, N.Y.
WORKS: ALLIANCE AND BARBERTON, O.; AUGUSTA, GA.

Utility company's own record puts Nonpareil in 18 turbines



A large midwest utility company, operating wide-spread plants, installed Nonpareil Turbine Oil in some of the turbines at two stations. Operating records were kept of all oils used in the company's turbines. Samples of the oils were tested periodically by the Chief Chemist. A study of the records over a period of years revealed that in the turbines lubricated with Nonpareil:

. . . the neutralization number remained at a constant low level.

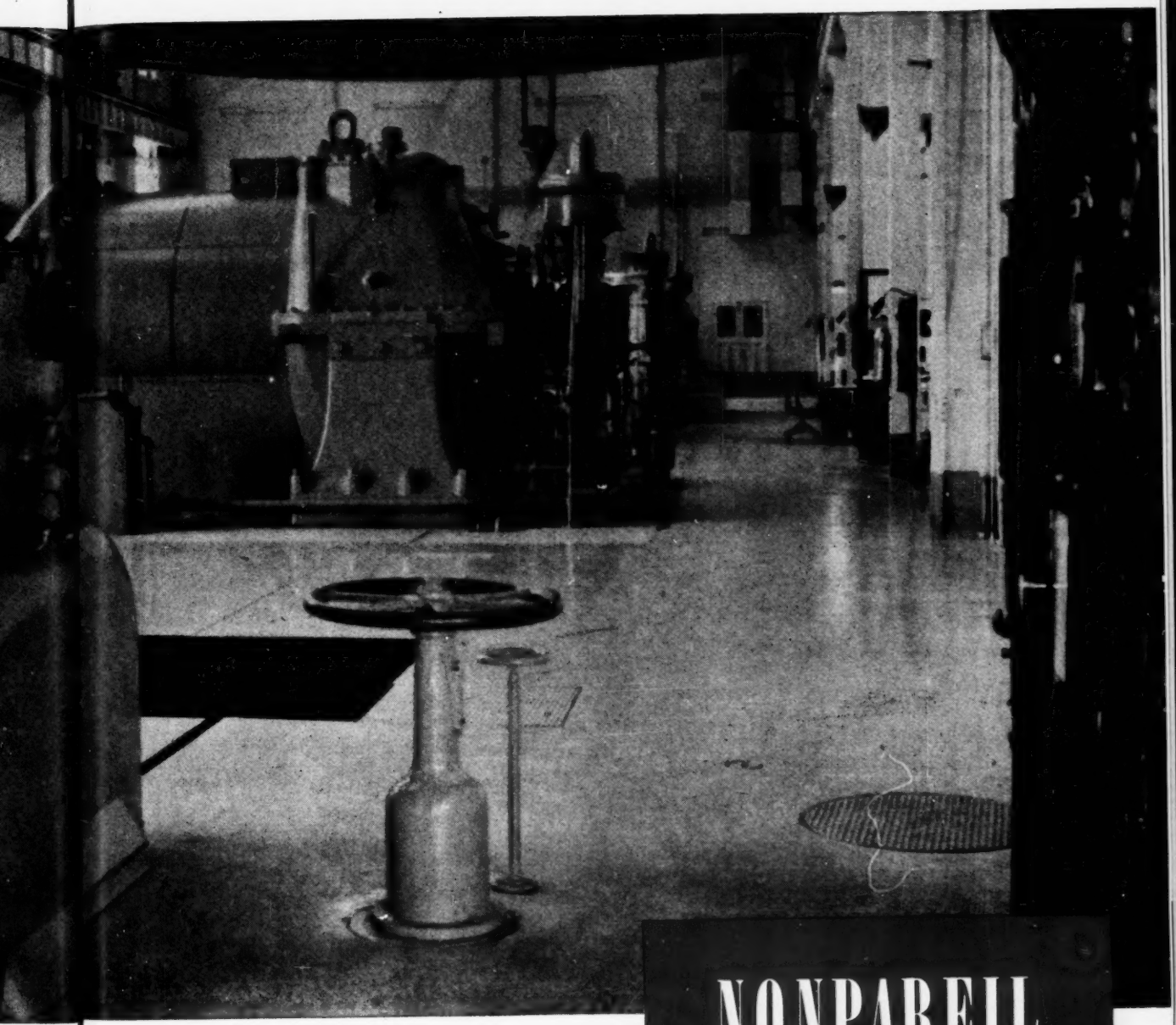
. . . there was no down time for cleaning the oil system or for changing oil.

. . . the over-all cost of operation was lower, while the earning power was greater because turbines were on the line longer.

Naturally, the decision was to switch to Nonpareil for all units. To date, 18 turbines with a total capacity of 211,000 KW are lubricated with Nonpareil.

Ask a Standard Oil Lubrication Engineer about nearby power plants where you can check for yourself the record Nonpareil is making. Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.

STANDARD OIL COMPANY (INDIANA) STANDARD SERVICE ST



NONPAREIL

TURBINE OIL

STANDARD OIL COMPANY (INDIANA)

STANDARD SERVICE

Fully

...THE HAGAN DIFFERENTIAL MASTER

You get the full benefit of automatic combustion control only when you have a combustion control system which is *fully* automatic.

You are not getting full benefit if manual adjustment is needed when there is a change in fuels, when a pulverizer is shut down, when coal gets wet, or when feeder characteristics change. You lose not only the time required to make the adjustment, but also the time spent in watching for the need of it.

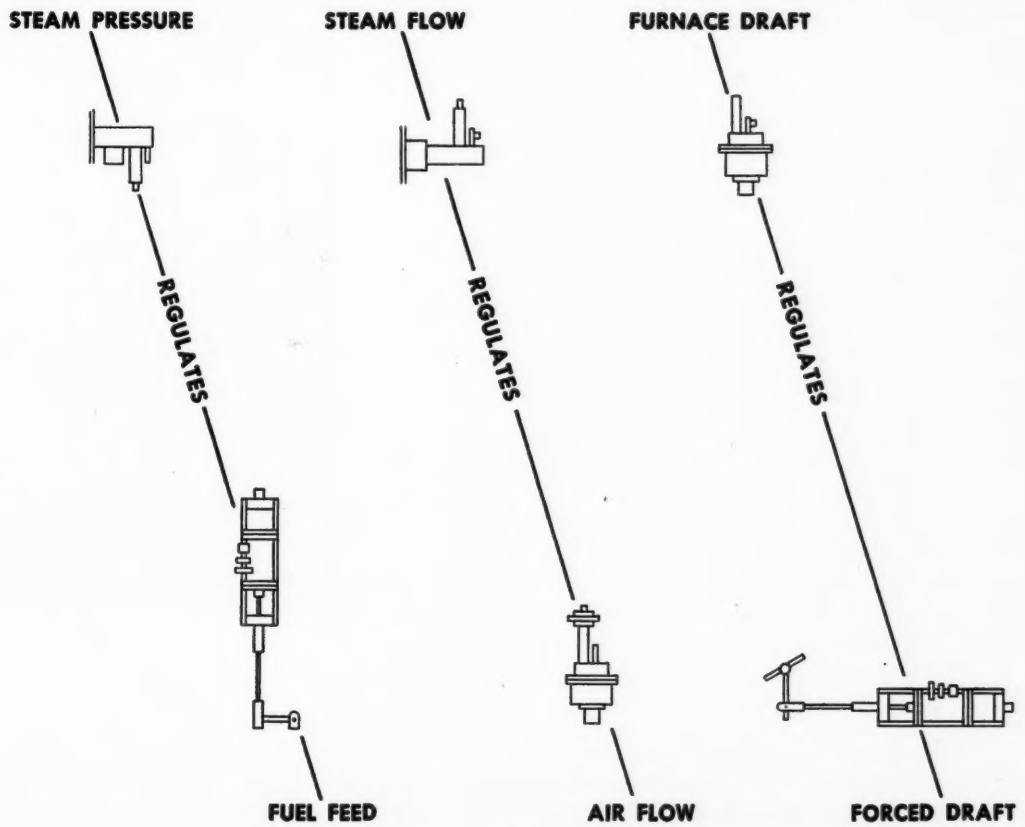
The Hagan Differential Master method of combustion control *is* fully automatic. The method employed is simple. A Hagan Master Sender, which is sensitive to steam header pressure, controls heat input in accordance with demand. A Hagan Differential Master Sender, measuring steam flow, regulates air flow. The boiler unit itself thus becomes a calorimeter of heat input.

The Hagan Differential Master system is in service with boilers burning gas, oil, pulverized coal and various combinations of these fuels. Boiler sizes in these installations range from 30,000 lb./hr. at 200 p.s.i. to 650,000 lb./hr. at 1,800 p.s.i. In every situation it has proved to be accurate, reliable, and easy to operate.

Hagan engineers will be glad to show you the advantages offered by the Differential Master method in your plant. Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

automatic

METHOD OF COMBUSTION CONTROL

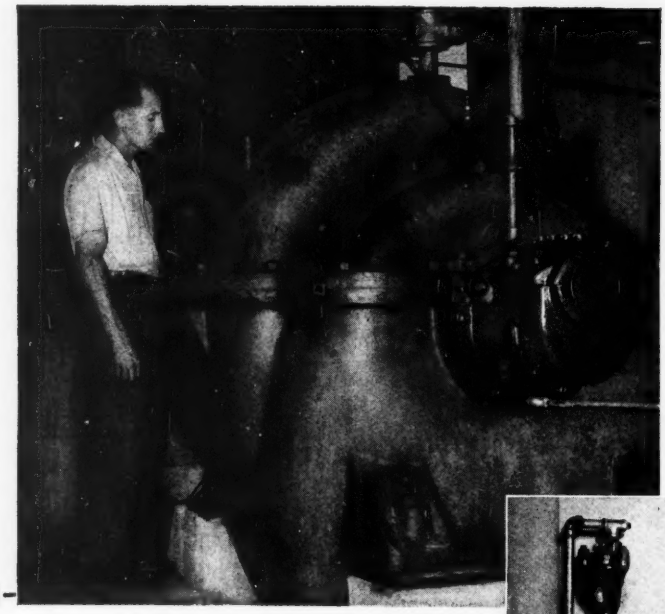


HAGAN CORPORATION

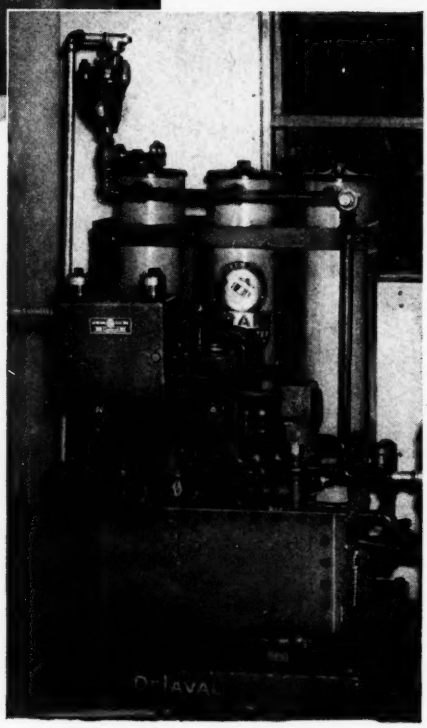
HAGAN
HALL
BUROMIN
CALGON

BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
THRUSTORQ FORCE MEASURING DEVICES

DETROIT PUBLIC LIBRARY



AT ROCHESTER PUMPING STATION—



THE DE LAVAL "PURI-FILTER" REMOVES DIRT AND CARBON

AT this pumping station, a De Laval centrifugal pump, direct-connected to a Chicago Pneumatic Diesel engine, pumps water from Hemlock Lake to Rochester. The Diesel lubricating oil at this pumping station is purified by means of the De Laval "Puri-Filter".

The "Puri-Filter" consists of the De Laval "Uni-Matic" Oil Purifier in combination with several Fram "Filcron" Filters. Dirt and water are removed from the oil by means of centrifugal force, the water being discharged continuously. The colloidal carbon is removed by the Fram Filters. Thus the oil is given maximum purifying effect at all times, providing Rochester with a safeguard for its all-important water supply.

The "Puri-Filter" is a compact unit furnished completely piped up, ready to run. It is the "natural" Diesel engineers have been waiting for to enable them to keep their lubricating oil in the cleanest possible condition.

THE DE LAVAL SEPARATOR COMPANY
165 Broadway, New York 6 427 Randolph St., Chicago 6
DE LAVAL PACIFIC CO., 61 Beale St., San Francisco 5
THE DE LAVAL COMPANY, Limited, Peterborough, Ont.

DE LAVAL
OIL PURIFIERS

FOR MOST DEPENDABLE POWER PRODUCTION

A SUPERIOR VALVE STEM PACKING

GARLOCK 117 Valve Stem Packing is manufactured from long fibre asbestos yarn and lubricated with a special heat-resisting compound. "Packed with Quality" from raw material to finished product, GARLOCK 117 gives superior service on stems of valves of all types operating against steam, hot or cold water, or oil.

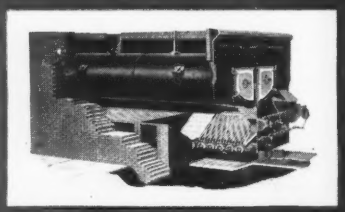
THE GARLOCK PACKING COMPANY
PALMYRA, N. Y.

In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

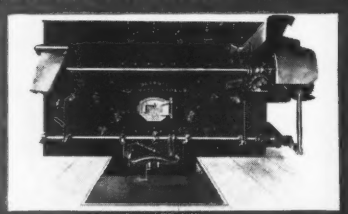
GARLOCK 117—furnished either braided or twisted in all sizes from 1/16" to 3/4".

GARLOCK 117

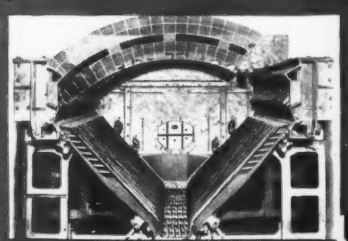
PROGRESS THROUGH THE YEARS DETROIT STOKERS *past...*



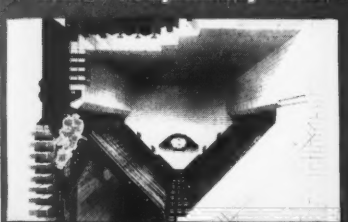
1898 First Detroit Automatic Stoker. Screw Feed.



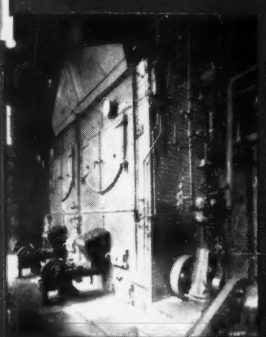
1902 Improved Detroit Stoker. V Type Screw Feed.



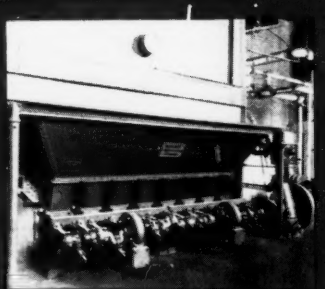
1907 First Detroit V Type Stoker. Reciprocating Feed.



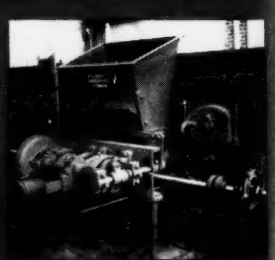
1910 Detroit V Type Stoker with Detroit flat arch.



1919 First Detroit Underfeed Stokers.



1919 First Detroit Multiple Retort Stoker.



1923 First Detroit Double Retort Stoker.

HALF A CENTURY

50 YEARS OF LEADERSHIP

Building Stokers Exclusively

On this our Fiftieth Anniversary, we express our appreciation of the confidence placed in us by many Engineers, Architects and satisfied users, for their favorable consideration of our Stokers. Without their cooperation and approval, the present standing of our Company in the Industry could never have been achieved.

To them we say:

"Thank you, and we trust our efforts in the future will warrant your continued patronage."

DETROIT STOKER COMPANY

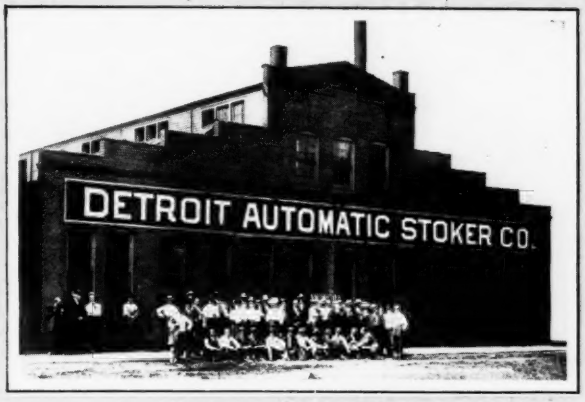
MAIN OFFICE AND WORKS—MONROE, MICHIGAN

SALES AND ENGINEERING OFFICE,
GENERAL MOTORS BUILDING, DETROIT, MICHIGAN

Offices in all Principal Cities

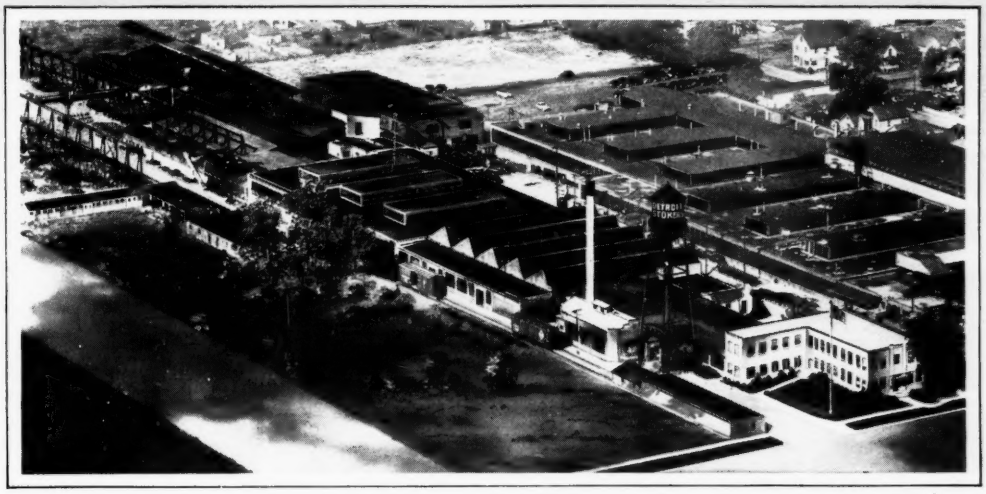
1898—1902

First Detroit Stoker Plant, located in Detroit.



1902—1922

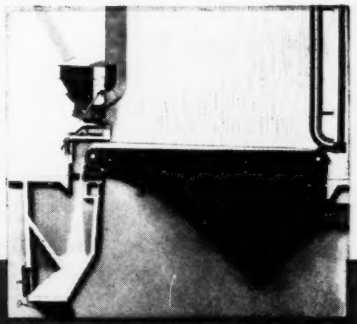
Second Detroit Stoker Plant, located in Detroit.



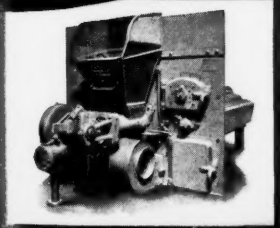
1948 Present Detroit Stoker Plant—Monroe, Michigan. Production of Detroit Stokers in 1948 has reached an all time high due to universal demand.

Fifty Years of Experience in combustion engineering and building stokers exclusively.

...and present



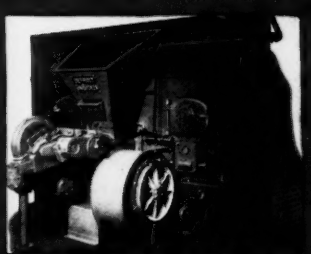
1938 Detroit RotoGrate. First continuous ash discharge spreader stoker with forward moving grate.



1925 First Detroit UniStoker (motor and fan direct connected).

1928 First Detroit Junior LoStoker.

1932 First Detroit (spreader) RotoStoker—Still in operation.



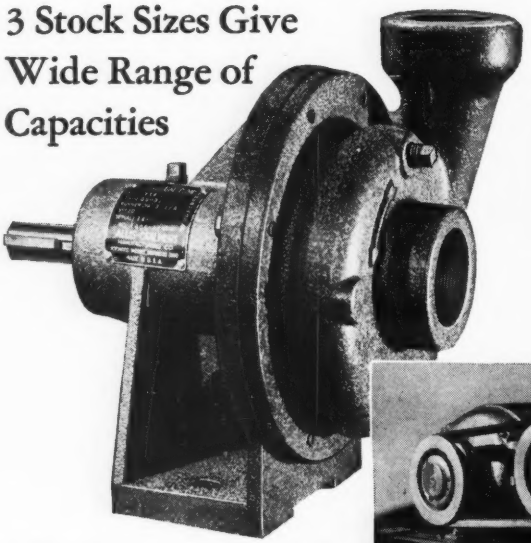
1937 UniStoker with Detroit Adjustable Coal Feed Control.

BUY THIS NEW PUMP

"Off-the-Shelf"

IT HAS MANY APPLICATIONS

3 Stock Sizes Give Wide Range of Capacities



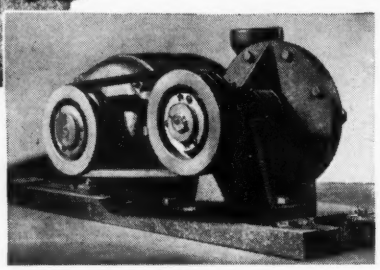
THE NEW "Pedrifugal"* Pedestal Type CENTRIFUGAL PUMP

THROUGH SIMPLE CHANGES in V-belt drive, impeller or casing these new pumps meet all average pumping requirements up to 500 gpm and heads to 100 ft.

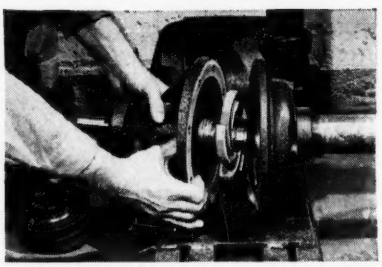
They were designed for the average user, who does not need a pump of special design or specification, but who does want a thoroughly reliable pump at a reasonable price, that he can buy right out of stock, and adapt to his needs.

The new "Pedrifugal" pump is built up to highest Allis-Chalmers standards in design, materials and workmanship. It is thoroughly tested, and backed by 65 years of engineering leadership in the design and construction of fine centrifugal pumps. Find out more about this new pump at your nearest A-C office or dealer. For specifications, ask for Bulletin 52B6691. ALLIS-CHALMERS, MILWAUKEE 1, WISCONSIN.

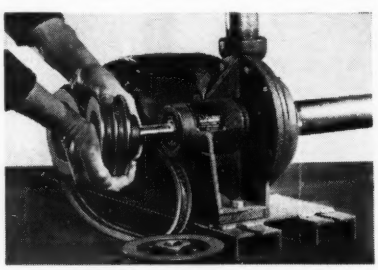
A 2306



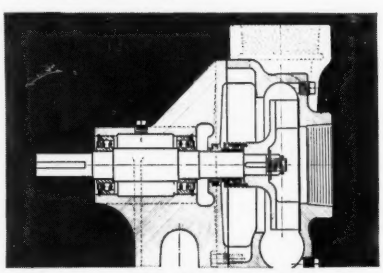
BUY IT "OFF THE SHELF" — Pump can be bought "bare" or as a complete unit pump motor, Texrope drive and welded steel base Also can be coupled or belted to a motor, a gasoline engine or power take-off which you already have.



DESIGNED AND BUILT FOR SIMPLIFIED MAINTENANCE — All moving parts quickly accessible without disconnecting pipes. No packing rings to replace . . . bearings have 3 to 5 year supply of grease under normal operating conditions.



V-BELT DRIVE GIVES GREAT RANGE OF CAPACITY — The Pedrifugal pump is specially designed for flexible TEXROPE V-belt drive Changing one sheave quickly changes speed and capacity of the pump . . . gives you great flexibility.



HIGH GRADE CONSTRUCTION — Two large ball bearings, grease sealed . . . High grade mechanical shaft seal . . . Heavy 1 in. machined shaft with *key ways* and impeller lock nut . . . Bronze open type impeller . . . Heavy, generous design throughout.

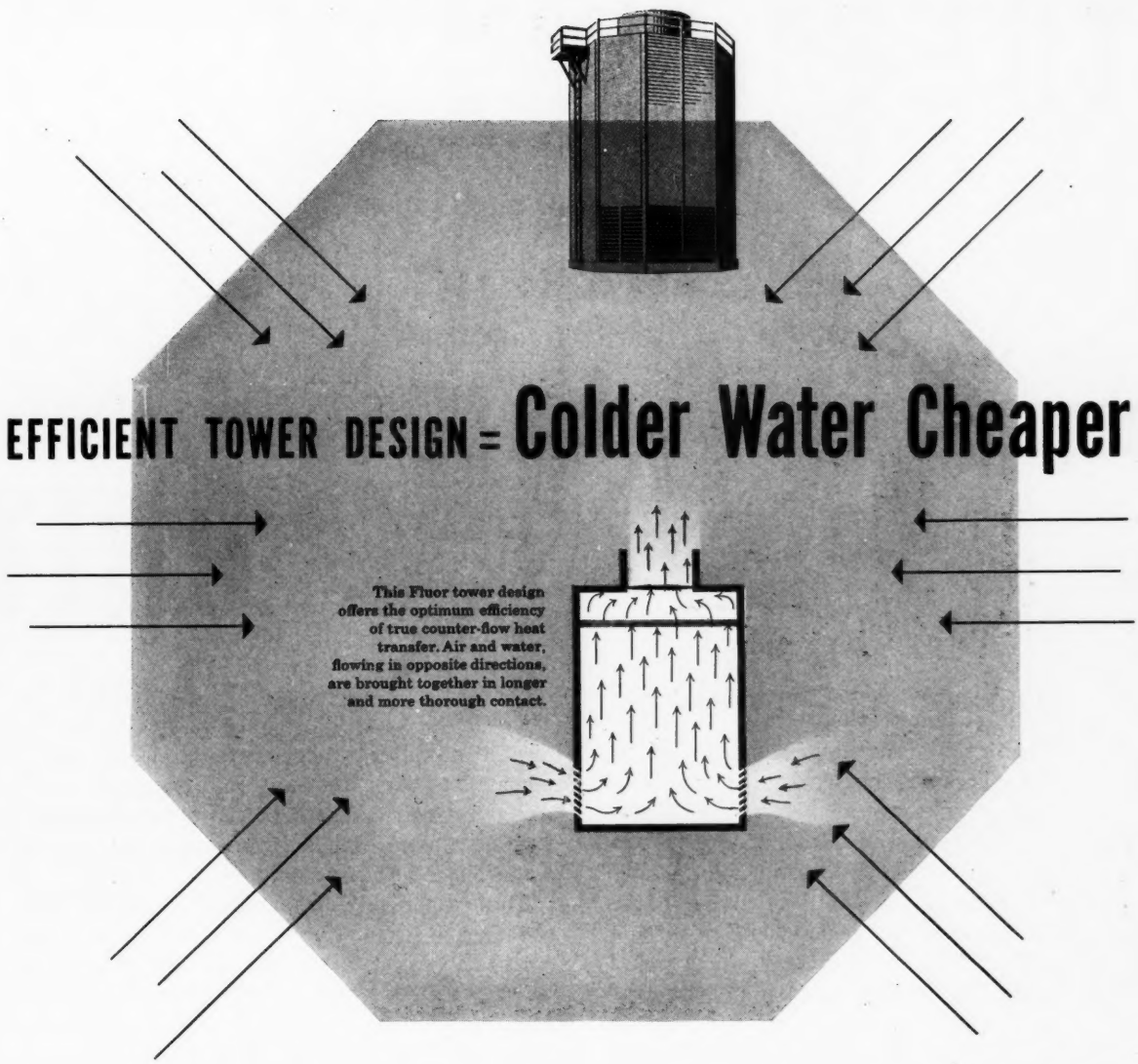
*Allis-Chalmers Trademark

ALLIS·CHALMERS

One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products

A CENTURY OF SERVICE to Industry THAT MADE America Great

EFFICIENT TOWER DESIGN = Colder Water Cheaper

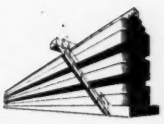


This Fluor tower design offers the optimum efficiency of true counter-flow heat transfer. Air and water, flowing in opposite directions, are brought together in longer and more thorough contact.

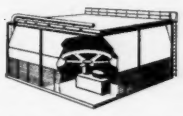
Cheaper? Yes, and here's why: Exhaustive field tests reveal the presence of "dead corner areas" in the conventional induced draft cooling tower, which seriously impair performance.

The new octagonal design of the Fluor "Counterflo" Tower not only eliminates stagnant corner areas, but provides a greatly increased intake area from six sides, thus assuring more uniform air distribution within the tower.

Add to this efficient tower design such other Fluor firsts as the patented upspray "Spirodome" water distributing system, proper design and arrangement of grid decking to assure longer air-water contact, fan and gearing developed to give long service life, and rigid time-resistant construction throughout—and you'll find that they all add up to lower operational costs—which means colder water cheaper!



Fluor areator atmospheric cooling towers are recommended where conditions make this type most practical.



The Fluor Fin-Fan cooling unit has a wide range of utility throughout industry.

BE SURE WITH FLUOR

FLUOR

PRODUCTS : *Cooling Equipment, Mufflers, Gas Cleaners, Pulsation Dampeners*

SERVICES : *Designers and Constructors of Refinery, Chemical and Natural Gas Processing Units*

THE FLUOR CORPORATION, LTD., *Los Angeles 22* · NEW YORK · PITTSBURGH · KANSAS CITY · HOUSTON · TULSA · BOSTON

THE VU UNIT

for modern performance standards

For an exceptionally wide range of steam requirements – capacities, pressures and temperatures – the VU Unit assures overall performance which measures up to the best modern standards . . . as proved by records of hundreds of installations.

One of the principal reasons for the success of the VU design, originated by Combustion Engineering in 1925, is the principle of symmetry which makes every longitudinal section through the unit the same as every other.

Think what this means. Since each longitudinal section is identical . . . and the front-to-rear course of the gases assures practically constant temperature and mass flow at any given line crosswise of the unit . . . the performance of each section is identical. Therefore identical sections can be combined to provide the desired capacity at optimum overall efficiency.

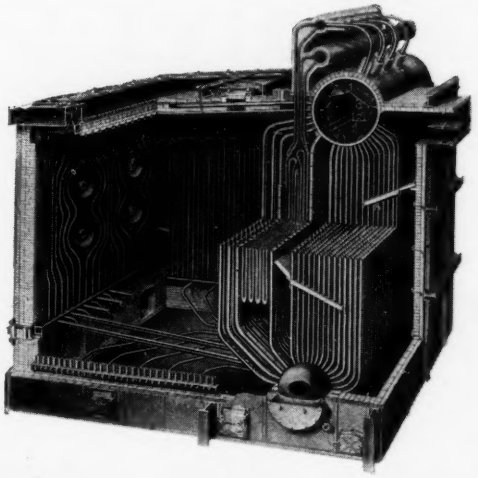
Symmetrical design eliminates lazy tubes since each longitudinal section has the same furnace volume, same evaporative surface, the same amount of water, producing the same amount of steam. Moreover, the uniform release of steam along the entire length of the drum eliminates surging water level and periodic carry-over of water slugs with the steam.

These operating advantages, combined with features assuring dependable service and low maintenance cost, have resulted in the selection of VU Units for installations throughout the United States and Canada and in many foreign countries. Aggregate capacity of these installations is now more than 70,000,000 pounds of steam per hour – a fact which speaks for itself.

The three units here illustrated comprise the VU family. They provide for capacities from 15,000 to more than 300,000 lb per hr, for pressures up to 1000 psi and for steam temperatures up to 900 F, or higher. They are adaptable to the use of any fuel or method of firing. They represent a complete answer to any and every specification of steam requirements within their capacity range.

B-141-A

COMBUS

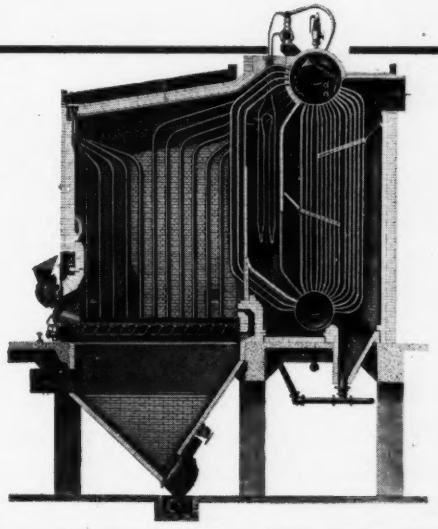


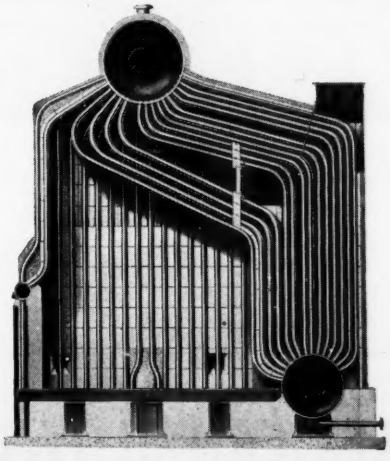
Type VU Steam Generator (for the higher capacity range)

This unit, the original VU design, may be fired by pulverized coal, oil or gas, or any combination of these fuels. Available for capacities up to 300,000, or more, lb of steam per hr, pressures up to 1000 psi and steam temperatures up to 900 F, or higher. Furnace bottom may be as shown or may be of hopper type. Economizer or air heater surface may be added.

Type VU Steam Generator (for the middle capacity range)

In this VU design, shown equipped with a C-E Spreader Stoker, the furnace proportions and arrangement of water wall surfaces may be adapted for firing by any type of mechanical stoker. Design is also adaptable for firing by oil or gas. Economizer or air heater surface may be added. Approximate capacity range 25,000 to 100,000, or more, lb per hr.





C-E Package Boiler (for the lower capacity range)

This youngest member of the VU family is designed for industrial load conditions and particularly for plants having small operating and maintenance forces. Capacities range from about 15,000 to 50,000 lb per hr. Firing may be by spreader stoker, single-retort underfeed stoker, oil or gas burners. Any of these methods may be substituted for any other, should fuel market conditions make this desirable.

GÝROL FLUID DRIVE

FOR BOILER FEED PUMP CONTROL IS GETTING MORE AND MORE POPULAR!

Laboratory demonstration permits observation of rotating elements in an American Blower type VS class 6 Gýrol Fluid Drive for use with a 3600 RPM 2,000 H.P. Boiler Feed Pump.

Why?

Because Gýrol Fluid Drive saves power and is the proved means of providing the fine increments of speed adjustment required in the narrow speed range over which a boiler feed pump must operate.

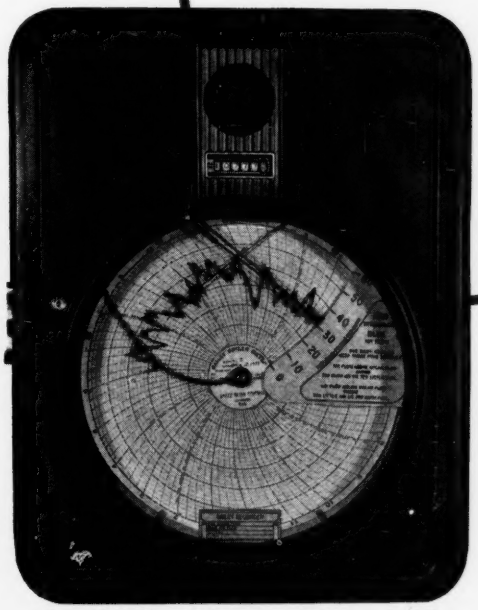
Interested? Send for descriptive bulletin 8019.

AMERICAN BLOWER CORP., DETROIT 32, MICHIGAN
CANADIAN SIROCCO CO., LTD., WINDSOR, ONTARIO

AMERICAN BLOWER

Division of AMERICAN RADIATOR & Standard Sanitary CORPORATION

Whatever Fuel You Burn— You'll Save Money with BAILEY CONTROLS



Bailey Controllers of this type accurately measure and record the factors upon which controls are based.

You'll get high Economy, Safety and Availability because Bailey Controls, working from the accurate measurements of Bailey Meters, do the right thing at the right time.

Bailey Combustion Control

1. Secures instant response to changes in load by regulating both fuel and air at the same time.
2. Maintains optimum fuel-air ratio as measured by Bailey Meters.
3. Gives you the same complete control, when you change fuel, or even when you burn waste.

Bailey Three-element Feed Water Control

1. Reacts quickly and yet retains high stability by accurately measuring Steam Output and Feed Water Input and by controlling the rate of feed water input so that it equals steam output.
2. Surge resulting from severe load changes is held to a minimum by the action of flow ratio and level components which may be adjusted to conform with boiler characteristics and operating conditions.
3. Needs no excess pressure control because its operation is based in part on an accurate measurement of feed water input.
4. Power used by feed pumps may be reduced by applying Three-element Feed Water Control directly to pump speed.

Bailey Steam Temperature Control

Maintains uniform temperature by controlling primarily from boiler load and by readjusting from temperature.

Bailey Feed Heater Control

1. Gives smooth efficient flow through heaters because its multi-element action incorporates accurate measurements of both flow and level.
2. Permits the use of smaller storage capacity heaters and tanks thereby reducing the cost of initial equipment.

Bailey Pump By-Pass Control

Protects pumps by opening a by-pass valve when flow through the pump drops below the safe minimum value.

BAILEY METER COMPANY

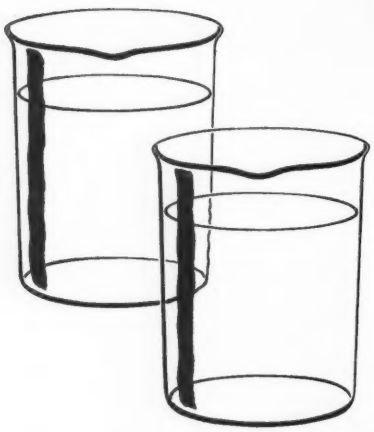
1040 IVANHOE ROAD • • • CLEVELAND 10, OHIO

Controls for Steam Plants

COMBUSTION • PRESSURE
FEED WATER • LIQUID LEVEL
TEMPERATURE • FEED PUMPS

A-99-1

Which water



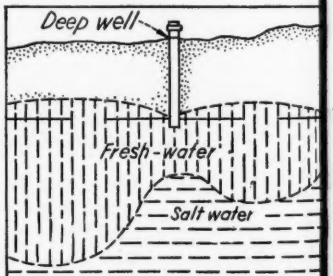
WATERS from different sources may be identical or radically different in appearance—but you can't tell by looking at them which source to choose for your plant.

Even the most thorough chemical analysis seldom provides more than a starting point for the study on which a decision must be based.

Along the Gulf Coast, for example, there is an area where river water contains much suspended matter and is otherwise contaminated, while well water is clear and of excellent quality. The well water is obviously preferable—but industries take a chance in using it, for salt water underlies the fresh water table, and any large use of fresh water may cut down the pressure, let the salt water in, and spoil the whole supply.

To plants near the sea coast, salt water is often a serious problem, even when they get their water supply from rivers. Tidal flow may cause brakish water many miles from the river's mouth, particularly in periods of dry weather. The Delaware River offers a marked example of this tendency. A Canadian plant has even gone to the length of damming a river below the raw water intake in order to keep sea water out.

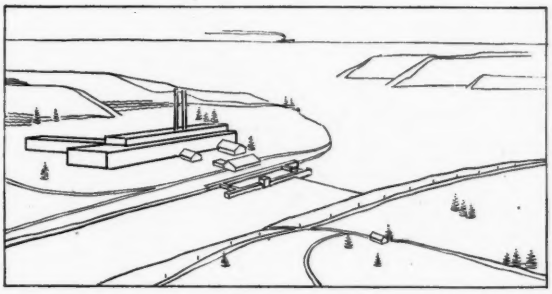
Variability of water sources is always a problem. One Louisiana plant, for example, had a choice between river water which was right "at the door," and water from an artificial lake nearly two miles away. Comparison of water samples showed that both waters would require coagulation, filtering, and softening. The lake water was better in quality, but there was the cost of a two-mile pipe line to be considered.



When samples of the two waters taken at various times of the year were studied, the decision was easy. At high water, the

HAGAN
HALL
BUROMIN
CALGON

is best for your plant?

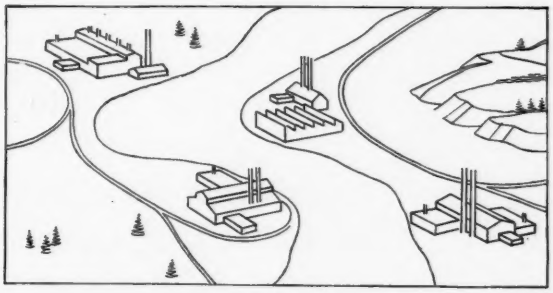


river became extremely muddy; at low water, organic contamination was great and there was even contamination by salt from wells drilled for oil at various points along the river. The lake water, however, was very even in quality, virtually the only change being a somewhat greater amount of suspended solids after heavy rains.

Contamination by industrial wastes from other plants may also be a serious problem, and this, too, may become more serious when water flow is low. In some instances, both the cost of treating contaminated waters and the cost of using alternative sources have been so high as to force a change in the choice of plant site.

These are only a few of the problems that may arise in selecting a water source. Water quality cannot be neglected—*water quality at all times, under all conditions and, as far as it can be foreseen, for the life of your plant.*

In the matter of water sources, as in all other industrial water problems, Hall Laboratories is pre-



pared to recommend procedures which, taking all factors into account, represent the most economic and efficient solution *in your specific situation.*

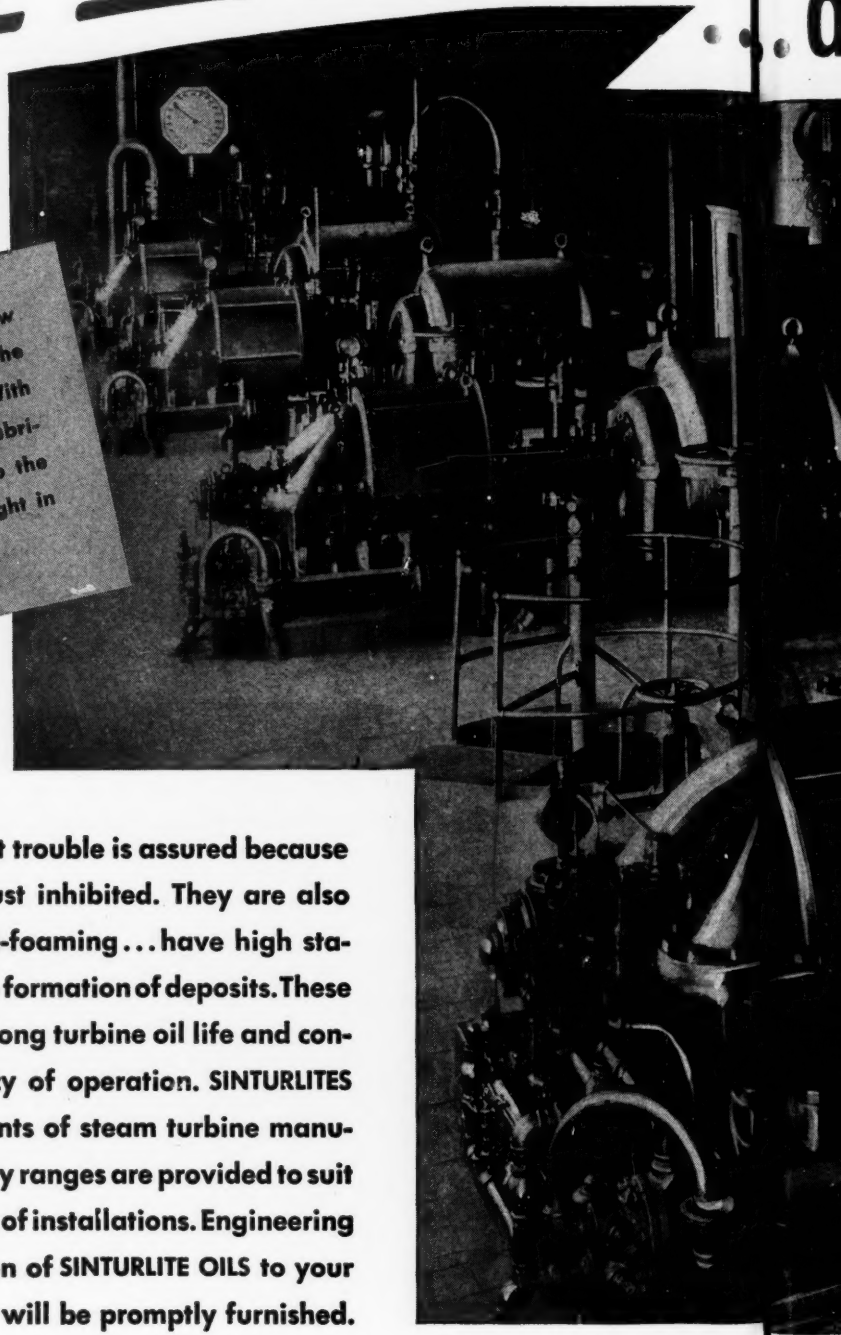
For full information concerning Hall service, write to Hall Laboratories, Inc., Hagan Building, Pittsburgh 30, Pennsylvania.

HALL LABORATORIES, INC.

(A Subsidiary of Hagan Corporation)

CONSULTANTS ON
INDUSTRIAL WATER TREATMENT
HALL SYSTEM OF BOILER WATER CONDITIONING
INDUSTRIAL WASTE RECOVERY AND DISPOSAL

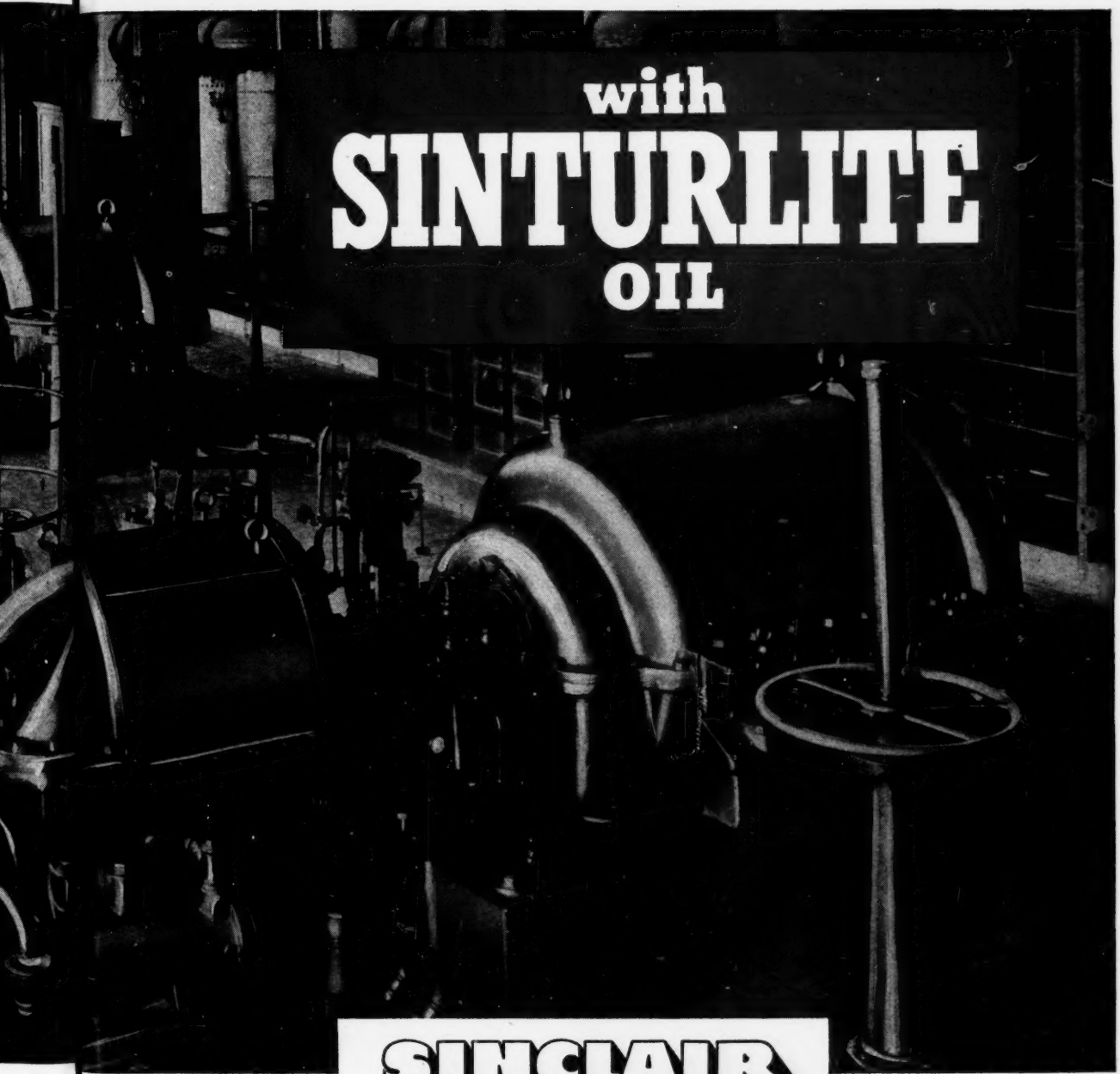
START-UP RIGHT



Rusting is a trouble common to new steam turbine systems unless the right oil is used at start-up. With Sinclair SINTURLITE OIL as the lubricant, the installation is off to the right start-up and it stays right in service operation.

Protection against rust trouble is assured because SINTURLITE OILS are rust inhibited. They are also anti-oxidant and non-foaming... have high stability and resistance to formation of deposits. These characteristics mean long turbine oil life and continuous high efficiency of operation. SINTURLITES fully meet requirements of steam turbine manufacturers. Five viscosity ranges are provided to suit varying requirements of installations. Engineering counsel on application of SINTURLITE OILS to your lubrication problems will be promptly furnished.

...and STAY RIGHT



SINCLAIR
INDUSTRIAL OILS

FOR FULL INFORMATION OR LUBRICATION COUNSEL
WRITE SINCLAIR REFINING COMPANY, 630 FIFTH AVE., NEW YORK 20, N. Y.

Meeting your steam requirements with CONTROLLED SUPERHEAT over WIDE LOAD RANGES

A METHOD of superheat control which successfully overcomes the disadvantages of methods such as damper by-pass, "desuperheating" by spraying water into steam, and others, has been developed and applied to Foster Wheeler steam generators.

The Foster Wheeler method operates by reducing the latent heat of the steam in the superheater inlet header. It differs from conventional desuperheating because no water is added to superheated steam. Simply, superheating becomes a controlled operation from inlet to outlet.

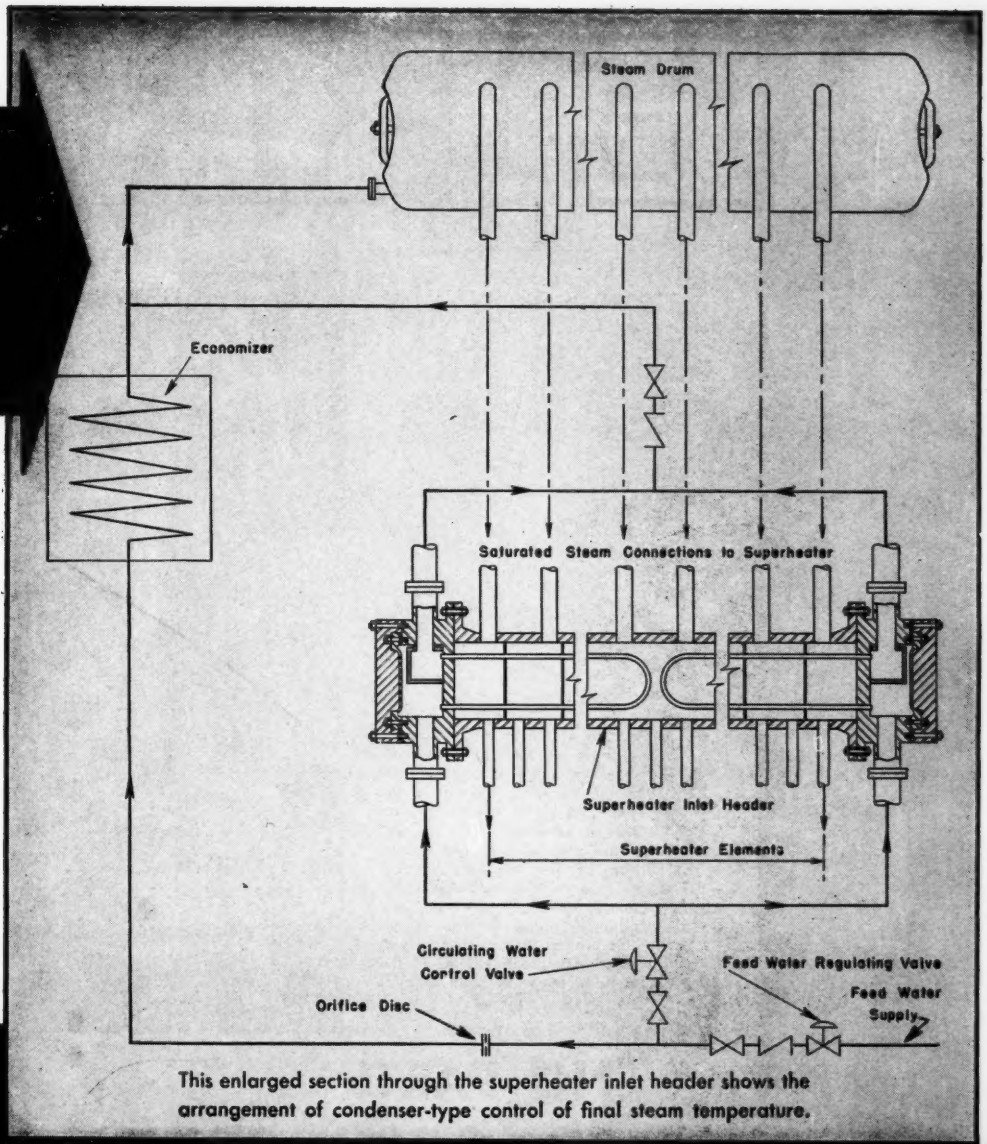
Boiler feedwater is diverted around the economizer and passed through tube bundles located in the superheater inlet header. This relatively cool feedwater condenses some of the entering cleaned and dried steam. The amount of moisture entering the superheater is regulated to provide positive and accurate control of final temperature. In addition to the wide range control possible when this device is used, superheated steam is not contaminated by water, and excessive metal stresses are avoided.

A reprint of an article describing in detail a specific application of Foster Wheeler condenser-type superheat control is available. Ask for B-46-20.

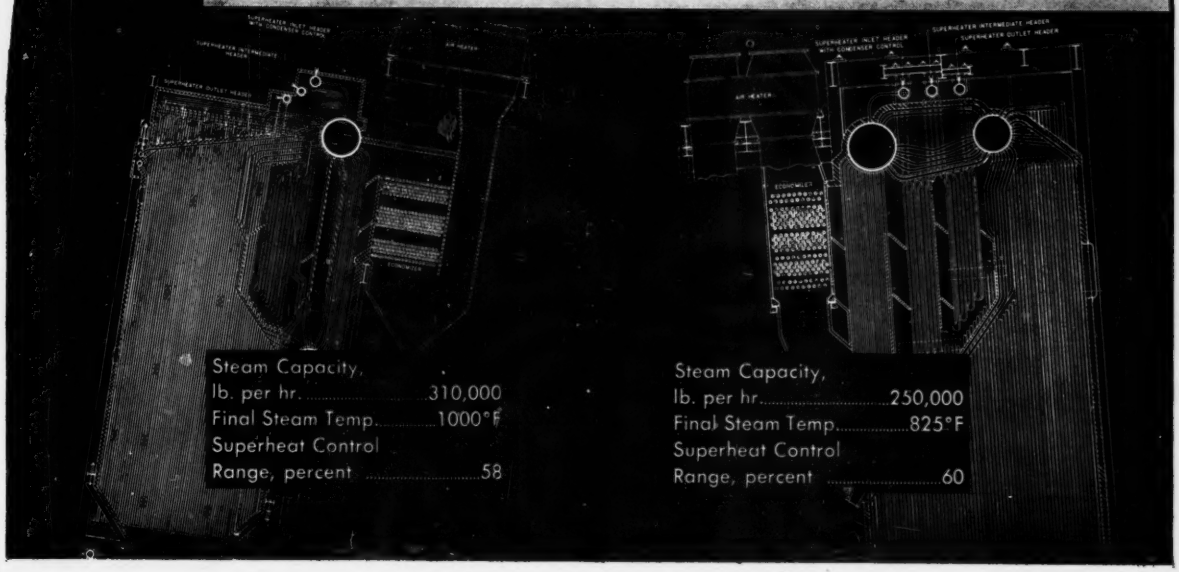
FOSTER WHEELER CORPORATION

165 BROADWAY, NEW YORK 6, NEW YORK

Steam Capacity, lb. per hr. 640,000
Final Steam Temp. 900°F
Superheat Control Range, percent 62
Steam Capacity, lb. per hr. 375,000
Final Steam Temp. 900°F
Superheat Control Range, percent 47
Steam Capacity, lb. per hr. 325,000
Final Steam Temp. 900°F
Superheat Control Range, percent 60



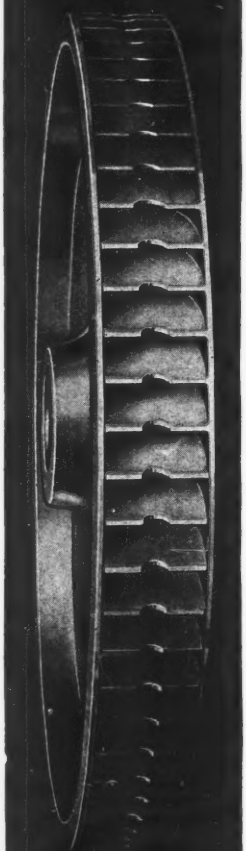
This enlarged section through the superheater inlet header shows the arrangement of condenser-type control of final steam temperature.

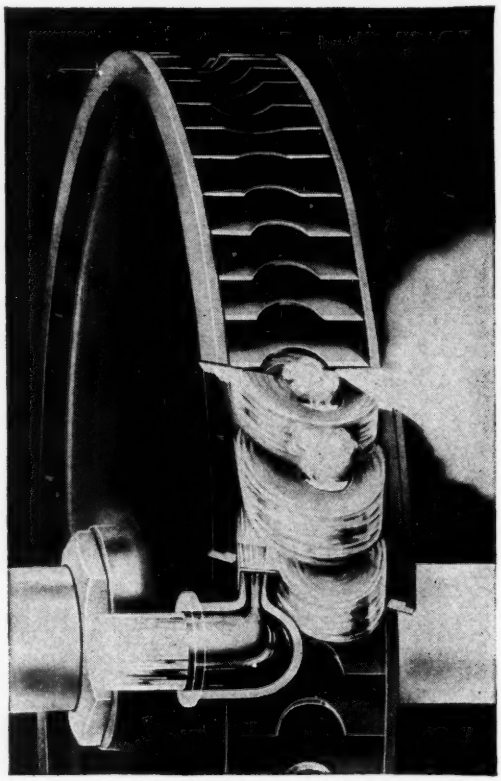


Steam Capacity, lb. per hr.	310,000
Final Steam Temp.	1000°F
Superheat Control Range, percent	58

Steam Capacity, lb. per hr.	250,000
Final Steam Temp.	825°F
Superheat Control Range, percent	60

TERRY





Action of steam in Terry wheel turbine. The steam issues from an expanding nozzle at high velocity and enters the side of the wheel bucket in which its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is caught in a stationary reversing chamber and returned again to the wheel. This process is repeated several times until practically all of the useful energy has been utilized.

NO PARTS TO LOOSEN OR WORK OUT

The rotor of the Terry Wheel Turbine is a single forging of special composition steel, in which a series of semi-circular buckets is milled. There are no separate parts to become loose or work out.

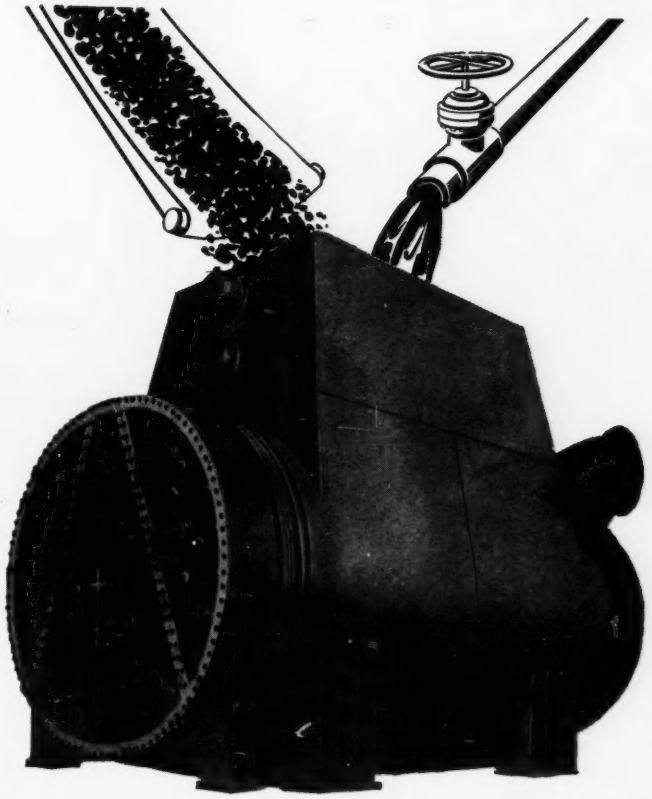
The power-producing action of the steam takes place on the solid curved backs of these buckets or pockets. Therefore close clearance is unnecessary and wear on the blades forming the pockets is of little consequence, as it does not materially affect horsepower or efficiency.

For detailed information about this effective construction and its advantages, write us on your business letterhead for a copy of Terry Turbine Bulletin S-116.

T-1172

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

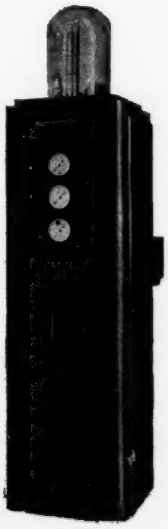
HOW MUCH FUEL DO YOUR CONDENSERS "BURN"?



Sounds like a foolish question, doesn't it? Actually it isn't—here's why: Every fraction of an inch of condenser back-pressure uses up fuel which costs you money but gives you no return, so in effect that fuel is burned up in the condenser and goes to waste—a total, and often unnecessary, loss.

The loss is unnecessary because condenser back-pressure is the result of lowered heat transfer and most transfer difficulties are due to micro-biological slime deposits on water-side surfaces.

These deposits can be economically eliminated—as has been proved in hundreds of installations—by chlorination properly applied to the cooling-water circuit. And, in addition to fuel savings, you'll gain these extra advantages, too: reduced labor costs, lower cooling water pumpage expense and less equipment out-of-service time.



Whether you use fresh, salt or brackish water and regardless of the type of cooling-water system, W&T Engineers with over thirty years' experience in water treatment will be able to show you a job-engineered W&T De-Sliming System for your plant that can save you money—often enough to pay for itself in less than a year on fuel savings alone. Why not call for an engineering study? No obligation, of course.

CD 27

WALLACE & TIERNAN PRODUCTS, INC.

CHLORINE AND CHEMICAL CONTROL EQUIPMENT

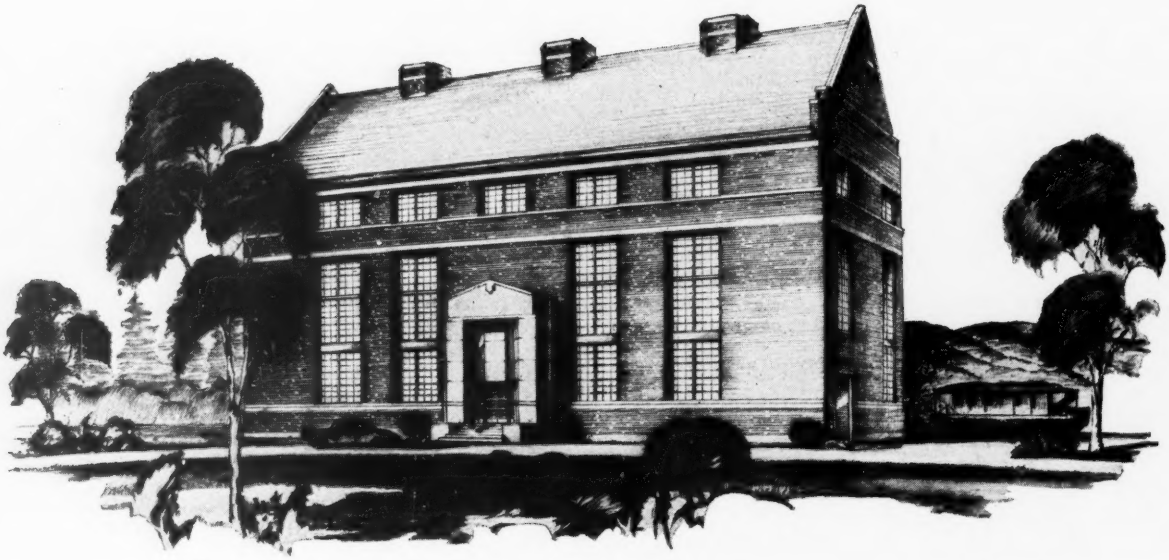
Belleville 9, New Jersey • Represented in Principal Cities

MODERN DESIGN AND EFFICIENCY GO HAND IN HAND WITH WICKES QUALITY AT *Michigan State College* EAST LANSING, MICHIGAN

This modern steam generation plant pictured below houses the *eleventh* Wickes Boiler installed at Michigan State College with space provided for the 12th unit.

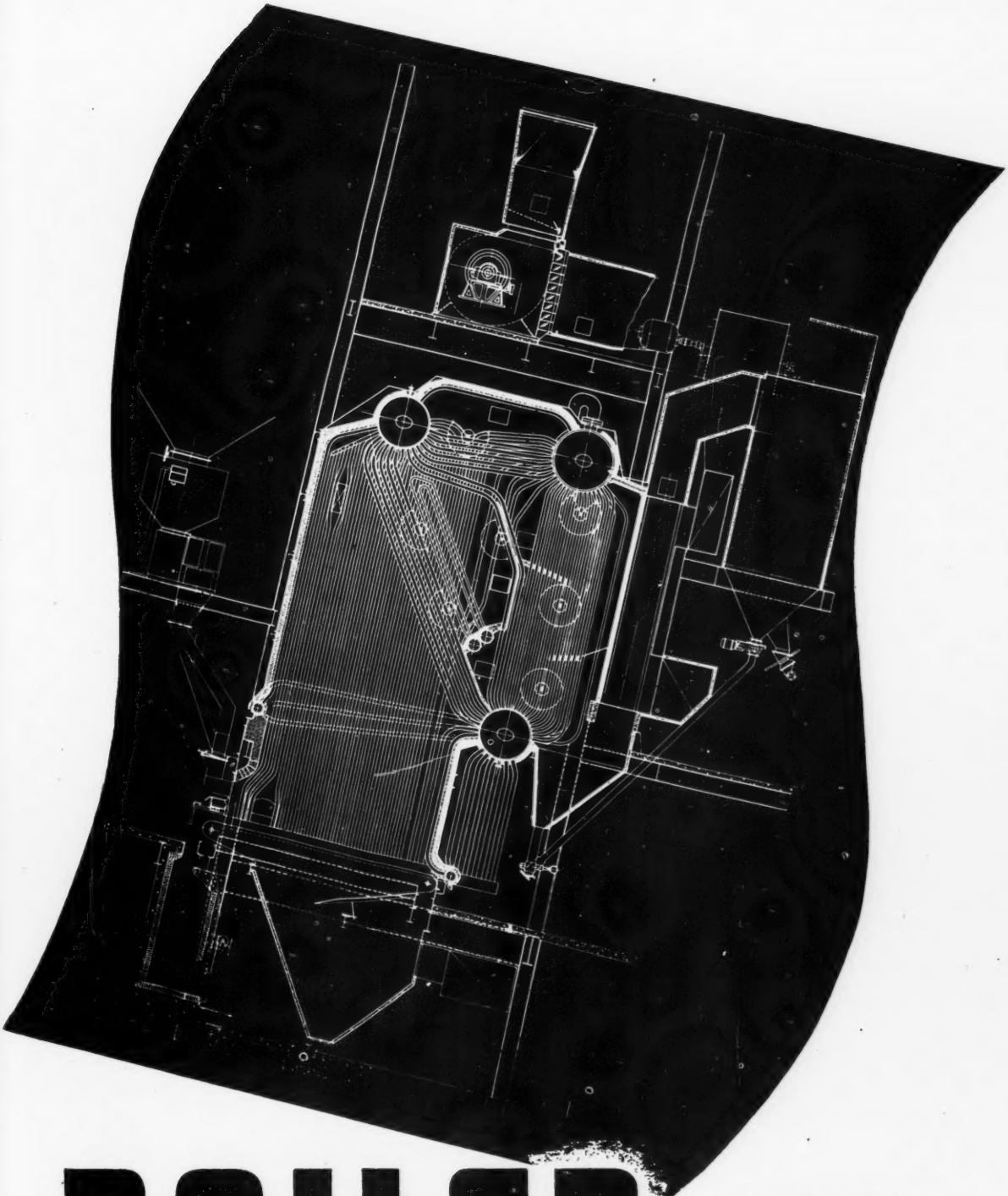
Working to the specifications of Claud R. Erickson, consulting engineer of Lansing, Michigan, Wickes designed a 3-drum boiler that makes this installation the *most modern, efficient generation plant* to be found at any educational institution in the country. Boiler specifications: capacity, 125,000 lb. per hr.; design pressure, 350 psi; total steam temperature, 550°F

Wickes has the engineers, the manufacturing facilities, and the skilled workmen to fill your requirements for *boilers of any type up to 250,000 lb. steam per hour and 850 psi.* Your inquiries will receive prompt attention.



WICKES

RECOGNIZED QUALITY SINCE 1854



BOILER

DIVISION OF THE
WICKES CORPORATION

SAGINAW, MICHIGAN

SALES OFFICES: Atlanta • Boston • Charlotte, N. C. • Chicago • Cincinnati • Denver • Detroit
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Chemical Industries Plants

Stick *Nalco* for *permanent* water treatment results!

Original research into water treatment problems is an important part of Nalco Laboratories work. Shown here is equipment used for the study of methods to keep boiler plant auxiliaries free from trouble.

Where chemistry is no mystery to plant operating men, the Nalco System thrives . . .

56.3% of all chemical industries plants using the Nalco System have been getting successful water treatment results for more than 5 years!

44.3% of the plants above have used the Nalco System *more than 10 years!*

41.9% of the plants in the over-10-years group have progressed with the Nalco System for *15 years or more!*

Such a record of continuous successful service has a point for you . . . If you are not already getting Nalco water treatment results, it may well be a profitable step to join the men who know chemistry — and stick to the Nalco System. Write for details today.

NATIONAL ALUMINATE CORPORATION

62[illegible] Place, Chicago 38, Illinois

Canadian inquires should be addressed to National Aluminate Chemicals, Ltd.
555 Eastern Avenue, [illegible]

— the Scientific System of Water Treatment for All Industry

Nalco

HELPFUL BULLETINS

Answers to many operating and maintenance problems will be found in these new bulletins and catalogs. List paragraph numbers of those you want on coupon below, detach and mail.

BOILERS AND ACCESSORIES

1 **Scotch Boiler**—Bulletin 504, 20 pages, illustrates a few of the Scotch type boilers that have been recently built by the company. It shows the practical application of different kinds of firing equipment, emphasizing their adaptability to a wide variety of working conditions in either high pressure or low pressure service. Johnston Bros., Inc.

2 **Water Tube Boilers**—Publication No. B 103, 15 pages, describes a line of water tube boilers. It contains photographs and cross-sectional views of typical installations with descriptions of the functions capacities and specific uses of the separate boiler systems. Dominion Bridge Co., Ltd.

3 **Pumping and Heating Units**—Bulletin No. 40, 16 pages, contains valuable information on this line of fuel oil pumping and heating units. Photographs, accompanied by descriptions, show many different type models. Two pages of ratings and specifications of various type units are included, as well as a diagram showing all parts of a typical unit. There is a brief description of a number of applications for which these units can be used. Contained in the bulletin is a conversion table and a heat-content-of-fuel-oil data sheet. National Airoil Burner Co., Inc.

4 **Boiler, Tank Accessories**—Catalog 11 on forged boiler and tank accessories has been issued. The bulletin gives complete buying information on manhole and handhole plates and yokes. The 20-page booklet contains illustrations, dimensional drawings, tables of weights and sizes and descriptive information. Comparable designations giving chemical composition and tensile properties of the products are presented. The Steel Improvement & Forge Co.

5 **Refractory Backing** — Bulletin 947 shows the advantages of using a flexible, unit supported, insulated refractory backing for close-spaced water walls. Cut-away drawings show the wall, and a plan view illustrates its details. Also included is a list of appropriate bulletins issued by the company. Geo. P. Reintjes Co.

6 **Dumping Grates** — Bulletin 890, 38 pages, is a well-designed brochure devoted to power-operated dumping grates, hand-operated dumping grates, and stationary grates. Each grate is illustrated and described. Numerous blueprints show functions of the dumping grates. Drawings show the various mechanisms in action. Detail photographs are included to show sections of the grates. The bulletin concludes with a series of photographs illustrating the actual uses of these dumping grates. Detroit Stoker Co.

7 **Magnetic Separator** — This 4 page bulletin explains the company's new line of non-electric magnetic separators. Included are drawings and photographs of various models for different kinds of uses. A description of the function and uses of each model accompanies the illustrations. Specifications of installations on various types of bases conclude the bulletin. Eriez Mfg. Co.

8 **Fuel Oil Heater Handbooks**—Bulletin No. 35 completely covers description, operation and construction of the company's line of fuel oil heaters. Included is a handy viscosity-temperature chart which shows at a glance the temperature required to reduce oil to the required viscosity. Other information included in the booklet consists of capacity tables and handbook data. The Whitlock Mfg. Co.

ELECTRICAL

9 **Fuses**—This folder, 4 pages, describes the significance of balanced lag in electrical fuses. It shows how unbalanced lag permits terrific waste, and how balanced lag stops unnecessary loss. Advantages of these fuses are stated and photographs and diagrams illustrate the important points. Pierce Renewable Fuses, Inc.

10 **Distribution Transformer** — Features and engineering data are included in this 4 page bulletin on distribution transformers. It contains a number of photographs of the transformer, a graph showing the time current characteristics of the internal fuse link, a diagram of the internal fuse link, dimensional drawings, mechanical data and list prices, and an impulse volt time curve. Allis-Chalmers Mfg. Co.

11 **Electrical and Lubricating Devices**—This folder, containing bulletins ranging in number from 1A to 40 and including Series H-66-T and E-88-T, shows the various kinds of electrical and lubricating devices that this company produces. Prices, diagrams, functions, photographs and special features are shown. Various types of fuses and oilers are clearly described. Dimensions and capacities are contained. Trico Fuse Mfg. Co.

12 **Signal and Control Equipment**—This new brochure of 5 pages describes a line of electrical signal and control equipment for public utility and industrial power plants. The booklet illustrates annunciators in various sizes and styles, audible signals, including horns, whistles, chimes, and vibrating and single stroke bells, a central sending station, relays and switches. Another section of the booklet is devoted to equipment using the print recorder which automatically prints a complete record in English of all station operations. In addition, a diagram board and a supervisory system for small municipal and industrial ac networks is illustrated. The Autocall Co.

13 **Built-In Motors**—There are 16 pages in this new Bulletin 516-D. The booklet is concerned with the company's Type CT, rolled shell, shaftless squirrel cage induction motors for built-in drives. Exceedingly well illustrated with both line drawings and photos, the bulletin covers every detail of the motors' construction, features and operation. Tables of horsepower ratings and photos of actual application of the motors to woodworking and metal working machinery are presented. Louis Allis Co.

14 **Axial Air-Gap Motor**—Bulletin 2760 is a 16-page bulletin which describes the many applications of the company's recently-announced axial air-gap motor. Following a detailed description of the motor, a series of photos showing representative applications of the unit are given. Tables and drawings of dimension data for horizontal, vertical and pivot base mounting and space and weight data are presented. Fairbanks, Morse & Co.

VALVES

15 **Valves**—A new ball-type valve is described in this bulletin of 4 pages. Two photographs, one showing a 2 in. full flow valve installed in pipe line, and another showing a 1½ in. full flow valve with "T" handle adapter, are included. A drawing illustrates the unrestricted pipe area and full flow features of the valve. The specifications of the valve complete the bulletin. Rockwood Sprinkler Co.

16 **Manifold Valve**—Bulletin A55, contains information about a draft gage manifold valve which simplifies draft gage line blow out. It contains a photograph of the valve, and a drawing which shows the draft gage valve in position between the draft line and the compressed air inlet. The Parker Appliance Co.

17 **Valves**—"Pneumatic Control Valves and Controller Accessories," is the title of this revised Bulletin 277-2 of 36 pages. Featured are a color page showing the various identifying enamel finishes offered on stabilflo valves; plates and tables of specification for control, needle type, poppet and butterfly valves. Separate sections deal with the vernier valvactor for high-accuracy positioning of valve plungers; and with a group of air switches and sub-panels for remote valve control. Information is supplied on the computing of valve sizes with tables and formulate for determining the size of the correct valve for a contemplated installation. The Foxboro Co.

18 **Valves**—Bulletin 100A, 32 pages, fully describes the various pressure regulators, pressure controllers, balanced relief valves, altitude valves, pump governors and strainers of the company. Included is a chart for pressure and temperature ratings for steam and water service—valve and strainer bodies; and a chart for aiding the engineer in selecting the proper valve for a given condition. All items are well diagrammed and described. The dimensions and prices are listed. The capacities are included. Davis Regulator Co.

19 **Gate Valves**—This is a 12-page illustrated folder describing a line of bronze gate valves. Cut-away drawings illustrate the various solid and split wedge, traveling, rising and stationary spindle, union and screw-in bonnet type valves. There is included a reference chart to figure numbers of the gate valves. The features of a new type Fig. 270-U bronze gate valve are described and illustrated. There is also a list of radiator and hose end gate valves. Jenkins Bros.

CONTROLS AND INSTRUMENTS

20 **Capacilog**—This is a 16-page technical data book on the capacilog. Operational diagrams, schematic drawings, charts and listings explain the diversified functions of the company's new strip chart recorder. The operation of measuring systems as deflection, potentiometer and resistance thermometer, electronic circuit and recording system are treated individually. Control switching actions are shown on a simplified diagrammatical chart. A section of the book gives instrument specifications and mounting dimensions. Wheelco Instrument Co.

JANUARY, 1948

POWER GENERATION

53 W. Jackson Blvd.
Chicago 4, Illinois

Please have the manufacturers send me without obligation the literature indicated by the following paragraph number:

.....

.....

.....

Please Print Clearly

Your Name.....

Your Title.....

Your Company Name.....

Company Address.....

City.....**State**.....

(If you prefer delivery at your home also fill in below)

Home Address.....

City.....**State**.....

21 **Flowrators**—Bulletin 26-B is a 4-page instruction manual devoted to master enclosed flowrators. It includes information on installation, operation, maintenance, disassembly, and reassembly of these flowrators. Diagrams illustrate each procedure. The last page has a full-spread drawing which shows each part in its proper place. Fischer & Porter Co.

22 **Orifice Flow Meter**—This new 12-page Bulletin 35-83-A on the company's flow meter of the orifice type has just been issued. The meter, for indicating, recording and integrating the flow of steam, gas and air, is described in detail and data or orifice plates, etc. are given. American District Steam Co.

23 **Ceitical Temperature Monitor**—This monitoring system which warns of approaching critical temperatures of bearings anywnere in the plant is described and pictured completely in this new 12-page bulletin. A series of diagrams shows how the system may be used in the plant and the several possible methods of reading and taking action upon warning. An explanation of how the system works is given and details of construction and parts are presented. The bulletin also has wiring diagrams and supplementary information. Thomas A. Edison, Inc.

24 **Water-Level Control**—Bulletin 451 7 pages contains a description of the water level control system at Parkchester. Included are photographs of feed water regulators and allied equipment that have been put into use in this development. Bailey Recorder charts show performance of steam flow and boiler water level. Northern Equipment Co.

25 **Steam and Liquid Controls**—Catalog 47, 48 pages, presents relative engineering data on this line of steam and liquid control equipment. Included are drawings, diagrams and photographs to illustrate the material. Also cited are instructions for usage, specifications, prices, dimensions, capacities, and operational data. Some equipment are diagrammed as part of a system. O. C. Keckley Co.

26 **Steam Heating and Temperature Control**—A line of steam heating and temperature control products is listed in this leaflet, 903-5M-1047. There are photographs and brief descriptions of each device. The leaflet includes thermostatic traps, traps, strainers, vacuum float vents, condensation pumps, vacuum pumps, thermotrols, and temperature controls. Capacities, sizes and maximum pressures are detailed. Sterling, Inc.

27 **Automatic Control**—Catalog V-2, 34 pages, illustrates and describes the 3000 series diaphragm control valves. The line presented includes both standard and special diaphragm control valves. Blueprints of the control valves, sub-assemblies and parts are included. Applications, design features and construction materials of the various type valves are fully detailed. In addition, the catalog contains working pressure data for the valve bodies. A number of specification sheets completes the booklet. Hammel-Dahl Co.

28 **Regulators**—Leaflet 145 contains engineering data on a line of regulators. Descriptions, diagrams and specifications are included as well as the features and special uses. Stets Co.

29 **Temperature Regulator**—This illustrated folder, 4 pages, describes a new line of self-contained, self-acting temperature regulators. A typical installation shows the cycle of operation. A sectional view of the regulator emphasizes the important features. The construction and operation of the valve is outlined. A full page of selection data includes a table of pressure-temperature ranges with class description; dimensions of the regulators; and capacity tables. Leslie Co.

30 **Instruments Catalog**—Pocket Catalog No. 17, 32 pages, is devoted to a description of a line of regulators and instruments. Each instrument and regulator is shown with a full-length photograph. A description follows which tells what are its uses, how it is mounted and how it is packed. Some instruments are priced. Defender Instrument & Regulator Co.

31 **Conductivity Measurements**—This bulletin, entitled "Conductivity Measurements in Boiler Operation," describes manual and automatic equipment for measuring the electrolytic conductivity of condensed steam, boiler water, raw water and return condensate. The bulletin also lists and describes conductivity cells and sample coolers. Industrial Instruments, Inc.

32 **Liquid Level Indicators**—Bulletin WG-1822, 16 pages, contains pertinent data on a line of remote liquid level indicators for boilers, heaters, storage tanks and other vessels in power and industrial process plants. Various drawings show where the indicators are installed. The working mechanism is detailed by a cutaway drawing. There are descriptions of operation and construction details. Typical installations of various indicators on boiler room panels are included. There are 6 photographs of controlling devices. Installation details are illustrated by a series of 11 wiring diagrams showing how to install the control unit and remote signals. Yarnall-Waring Co.

33 **Manometers**—A group of manometers are featured in this Bulletin 171. Included are a number of photographs, a drawing of the over pressure safety traps, descriptions of the various type manometers and catalog tables. The catalog tables present four different kinds of series with their scales in inches of water or mercury, their dimensions and their connections. F. W. Dwyer Mfg. Co.

34 **Instruments**—Catalog C-11, 12 pages, contains a line of measuring instruments. The purposes and uses of manometers are cited. Also included are standard scales for these instruments, list prices and a description of the uses and special features of the manometers. Photographs illustrate the material. One-half of the catalog is devoted to a description of a line of mercury pressure gauges. A list shows the ranges of the single-tube, two-tube and three-tube draft gauges. There is a photograph and a price list for each gauge described. The catalog closes with a price list of indicating fluids. The Meriam Instrument Co.

35 **Voltage Tester**—Catalog 61-001 contains relative information about a new voltage tester designed to test continuity of circuits (ac or dc), 110 to 550 v ac, 110 to 600 v dc, blown fuses, grounded side of line, grounded side of motor or appliance, etc. Action photographs are included, and eight ways to use the voltage tester are given. Ideal Industries.

PUMPS AND FANS

36 **Centrifugal Pumps**—Three bulletins, 713-1, 715-1 and 718-1, describing the company's types of centrifugal pumps were issued recently. They are respectively, 2, 12 and 2 pages in size. All three are well illustrated, contain complete specifications charts of performance and drawings and tables of dimensions. In addition, the 12-page bulletin describes materials of construction and gives information on details of construction. Goulds Pumps, Inc.

37 **Self-Priming Pump**—On the front cover of this 8 page bulletin is a diagram of the priming cycle of this self-priming pump. Included in the bulletin are a range diagram approximating the head-capacity range of the pumps, cut away drawings with parts description, photographs of a dismantled pump and of a typical installation, and four diagrams with dimensions of the pumps. There is also a description of how the pump works, its applications and its range. Allis-Chalmers Mfg. Co.

38 **Sewage Pumps**—Bulletin 250, 15 pages, describes a line of sewage pumps. Included is a cut-away drawing and complete specifications of a pump, and photographs of a pump stand and intermediate shafting with their specifications. Eighteen capacity rating tables show the relationship between various capacities to the total dynamic head in feet of water. Three other dimensional tables are accompanied by diagrams. A typical installation is also shown. American Well Works.

39 **High Pressure Pump**—Bulletin 244, 6 pages, includes pertinent data on a line of six stage, type TH high pressure pumps for pressures up to 1200 psi. Features of this bulletin are a large cutaway drawing showing the packed protective shaft sleeves; the grooved, labyrinth type, renewable wearing rings; the oversize first stage suction and impeller inlet; and a detail showing that the suction pressure is only on both stuffing boxes. Quality features are listed, and metal specifications, type TH pump are given. Warren Steam Pump Co., Inc.

40 **Centrifugal Pump**—Bulletin B-165, 8 pages, contains information about a single stage, end suction, vertically split case centrifugal pump for factories, utilities, etc. Typical installations are shown. Various types are illustrated with photographs. Two large dimensional drawings point out the construction details. "How to select a centrifugal pump" is shown by giving head-capacity and motor size tables. A typical illustration is included. By using the illustration and the three tables it is easy to see how the appropriate pump can be found. Peerless Pump Division, Food Machinery Corp.

41 **Centrifugal Blowers and Exhausters**—This 12 page booklet A-650, describes many applications of these blowers and exhausters. Design features are explained graphically, and operating characteristics and advantages are described. The booklet includes charts showing capacity ranges, conversion factors and graphs to aid in determining blower or exhauster requirements. United States Hoffman Machinery Corp.

TREATMENT

42 **Boiler Treatment**—Included in this 16 page catalog are descriptions of various methods of applying treating chemicals to boiler feedwater systems and boiler drums, and discussions of pretreatment of raw water make-up, application of chemical feeding equipment to pretreating operations, methods of treating boiler feedwater, constant rate feeding to feedwater system and direct to boiler drum. Diagrams show these various systems in operation. Proportioneers, Inc.

43 **Corrosion Prevention**—This leaflet describes the functions of a brine treatment for the prevention of brine, acid and oxygen corrosion. It also tells why the treatment is excellent for water used in air conditioning systems, internal combustion engine cooling systems, cooling towers. Magnus Chemical Co.

44 **Carbon Scale and Slag Remover**—This is a folder which explains the features of a slag remover. It describes this method of checking and removing soot, carbon scale and slag formation from the heating surfaces of all types of boilers. General instructions are depicted for use with coal and oil fired boilers. Garratt-Callahan Co.

45 **Chemical Solution Feeder**—Bulletin 305-A, 4 pages, describes a chemical solution feeder for use in water treatment, sewage purification and industrial waste treatment. Accompanied by a description are drawings of a chemical feeder with solution tank, a feeder with solution tanks and pump suction box and a feeder fitted with a suction box. Infilco, Inc.

PIPING AND HUMIDIFIERS

46 **Humidification**—Controlled humidification is the subject of this Bulletin No. 177, 12 pages. Colored drawings show how the humidifier can be either electrically or air operated. Photographs are included of various installations in different types of plants. Tables, drawings and pertinent data show in four full pages "How to Select" and "How to Install Humidifiers." One table shows the pounds of steam required to humidify 1000 cu ft of space with various outside temperatures and inside humidities. Another table gives the humidifier prices and capacities. Other tables are useful in determining whether steam supply pipes and return lines are adequate to take care of a humidifier installation. Armstrong Machine Works.

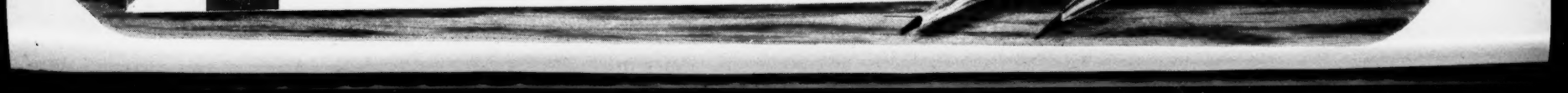
47 **Air-Eliminators**—Bulletin 701-A contains a line of heating specialties and automatic humidifiers for steam and hot water. Photographs and description accompany each item. In addition, the capacities and prices are listed. Maid-O'-Mist, Inc.

48 **Unions and Fittings**—This 4-page bulletin contains engineering data on a line of unions and fittings. Their features are described and illustrated by cutaway drawings. Attached to the bulletin are two leaflets containing price lists of the various models. Corley Co., Inc.

MISCELLANEOUS

49 **Diesel Engines**—This 4 page bulletin, Form 10311, describes new types ss turbocharged Diesel engines. The inside spread is devoted to hp ratings, fuel consumption curves, and an explanation of the new features and improvements. On the back page is a table and diagram listing ratings and dimensions. Ingersoll-Rand Co.

50 **Portable Vacuum Cleaner**—Complete description of a recently-announced vacuum cleaner for industry is contained in Bulletin 112D. This four-page bulletin describes in detail the operation and construction of the unit and lists a table of specifications for 2 models. The booklet is well illustrated. The Spencer Turbine Co.



LUBE MEMO

Easy way to end sticky valve trouble

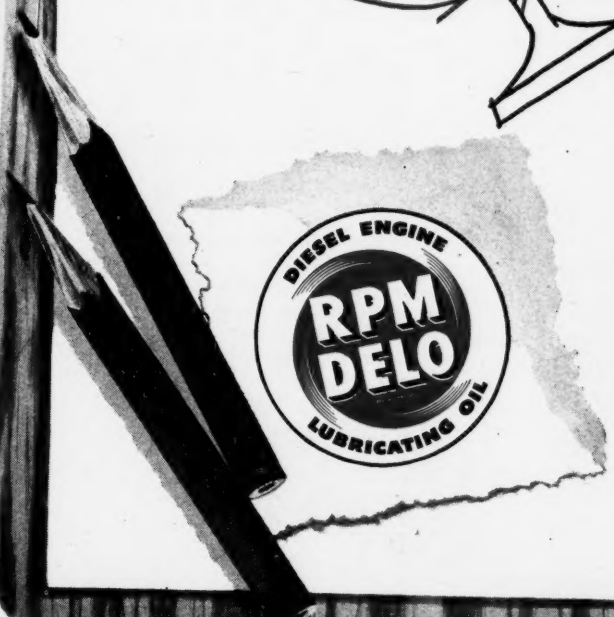
Sticky gum on our valves

Ex. valve on #1 isn't closing —loss of compression and power.

Nelson brags RPM DELO Oil keeps his valves clean as a whistle.

Nelson says compounds in RPM DELO Diesel Engine Lubricating Oil keeps valves free 3 ways:

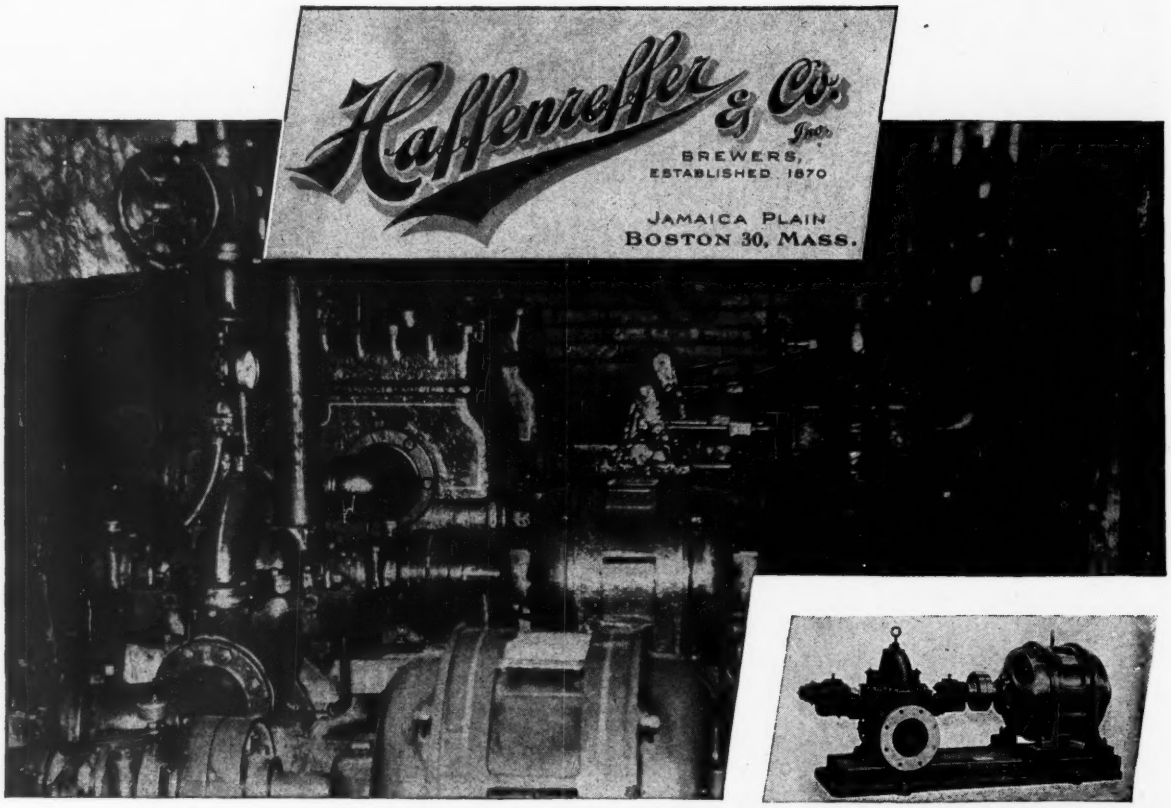
1. Anti-oxidant stops gum formation
2. Metal adherent keeps oil film on stem—prevents wear.
3. Detergent cleans away carbon deposits.



Mon.—lube change due—get RPM DELO Oil

STANDARD OIL COMPANY (CALIFORNIA) • San Francisco, Calif.
THE CALIFORNIA COMPANY • Denver, Colo.
THE CALIFORNIA OIL COMPANY • New York
STANDARD OIL (TEXAS) • El Paso, Texas

Another famous user of WARREN PUMPS!

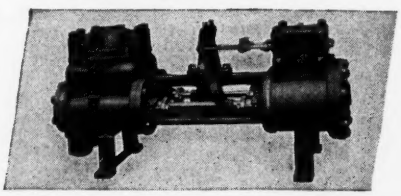


Haffenreffer and Co., brewers in Boston since 1870, depend on Warren Centrifugal and Reciprocating Pumps for efficient, low-cost, long-life pump performance, just as many breweries and widely varied industries have depended on Warren Pumps for the past half century.

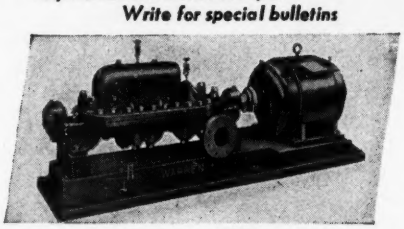
For 50 years Warren engineers have designed and built pumps that have solved the pumping problems of hundreds of plants. If you have a pump problem we invite you to write us, letting us have as much detailed information as possible. Our engineers will be glad to make recommendations, with no obligation on your part.

Warren Steam Pump Company, Inc.
WARREN, MASSACHUSETTS P-8

Warren DM and DL, Single Stage, double-suction centrifugal pumps are widely used on various general services. Special metals, capacities, heads, etc., are available to meet various operating conditions.



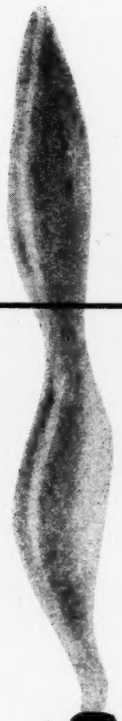
"Realwear" Horizontal Duplex Piston Pumps—a favorite for boiler feed, fuel oil pressure, oil transfer, general water services, etc. Type TM (below) Four and Six Stage for high pressure requirements in boiler feed, etc.
Write for special bulletins



WARREN PUMPS

Dearborn Treatment and Service Solved the Boiler Water Problem

in this Power Plant



● Five boilers of 5,000 hp total rating produce the steam for power generation and for heating dry kilns.

The make-up water, taken mostly from a near-by log pond, contains a high percentage of solids, including organic matter.

Dearborn internal treating method and test procedure was recently installed. Since then, among other advantages the time required to clean each boiler has been greatly reduced.

Dearborn Engineer studied all phases of the water problem . . . solved it . . . and now in his frequent service calls assists the plant engineer to maintain good boiler efficiency resulting from correct water treatment.

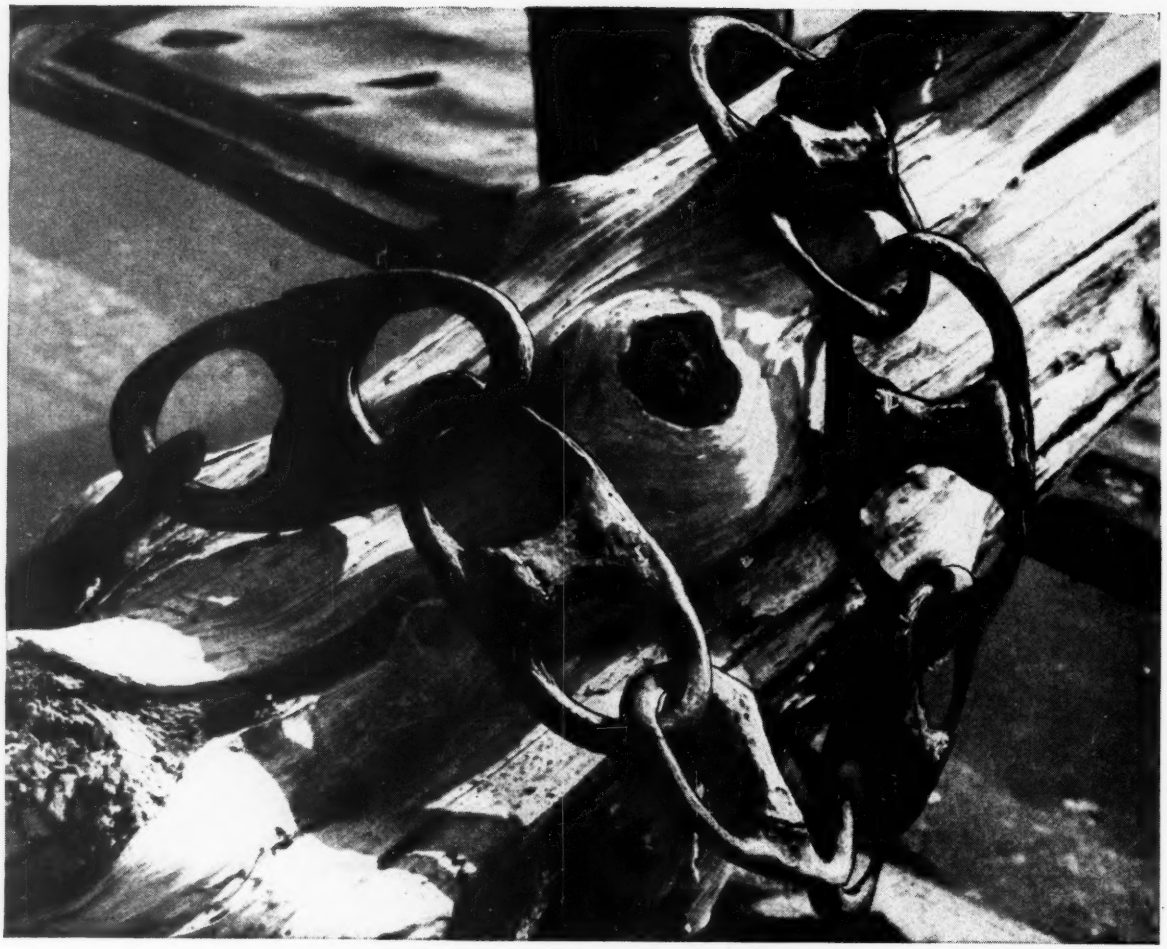
Dearborn

TRADE MARK REGISTERED

THE *Leader* FOR 60 YEARS

ENGINEERING SERVICE AND WATER TREATMENT

DEARBORN CHEMICAL COMPANY
Dept. F, 310 S. Michigan Ave., Chicago 4, Ill.



CHAIN REACTION

VERY OFTEN a single industrial lubrication problem in your plant, if allowed to run unchecked, can set off a whole chain of costly production hold-ups.

Rust or corrosion, for example, frequently unnoticed in its insidious early stages, may soon affect a vital piece of equipment or machine. Then, suddenly, an entire production line is thrown out of balance.

Furnishing expert counsel and advice on rust and corrosion problems is only one of the many ways Cities Service lubrication engineers can help you. These cost-conscious, production-minded experts are "professional worriers." Their recommendations for exactly the right grade of oils, greases, solvents or other petroleum products to meet your individual needs are based upon a sound, intelligent "situation analysis" made on the spot and backed by experience.

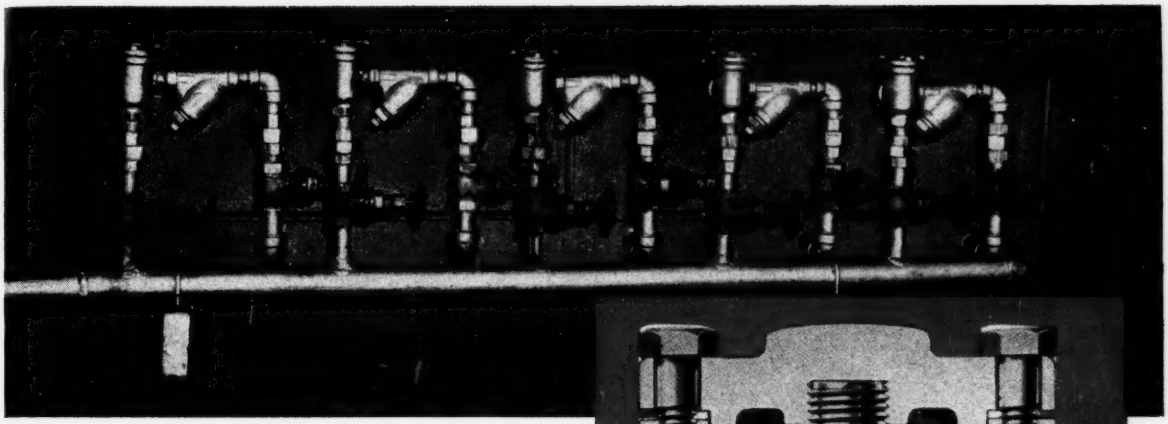
Moreover, behind the recommendations of a Cities Service lubrication engineer is the solid background of a company whose roots go back almost to the beginnings of the petroleum industry.

CITIES SERVICE

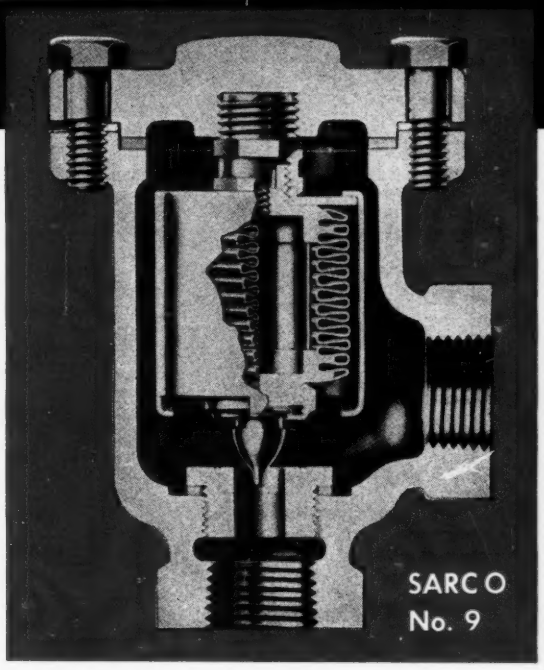
Why not let a Cities Service lubrication engineer do your "worrying" on all your industrial lubrication problems. Phone, wire or write Cities Service, Sixty Wall Tower, New York 5, N.Y. Room 6.

CITIES SERVICE *Means* GREAT *Service*

ALL THE WAY FROM THE REFINERY TO YOUR PLANT



Sarco No. 9 Thermostatic Steam Traps on ovens. More than 220 Sarcos are used in this plant.



WHY FORD MOTOR CO. INSTALLED SARCO No. 9 Steam Traps

in its Hegewisch Plant, Chicago, Ill.

The heating-up time on the ovens at the Ford plant in Chicago was reduced from three to four hours to less than an hour by using Sarco No. 9 Thermostatic Steam Traps on each individual coil. Production is more reliable and more uniform because Sarco No. 9:

(a) Requires less space.

(b) Will work satisfactorily regardless of pressure changes, making it unnecessary to change orifice due to change of pressure.

(c) Has rapid air venting due to larger valve orifice, allowing rapid heating up from cold start.

(d) Has one working part—the flexible bellow, thus reducing Maintenance cost.

(e) Is one of the few thermostatic traps made with a range from 0# to 225# steam pressure.

(f) Slight additional cost is more than offset by low maintenance cost.

189

SARCO SAVES STEAM

SARCO COMPANY, INC.

Represented in Principal Cities

Empire State Building, New York 1, N. Y.

SARCO CANADA, LTD., TORONTO 5, ONTARIO

NEW EQUIPMENT NEWS

Use the coupon below when you want further information on the equipment described on this page and following pages. Write the identifying letter or letters in the space provided, clip the coupon and send it to Power Generation, 53 West Jackson Boulevard, Chicago 4, Illinois

A Chain Hoists. The Chester Hoist Co., announces a new line of differential chain hoists made to meet present day demands of severe punishment, high rate safety and within a normal price range.

The construction features are full weight accurately cast sheave wheels, high tensile malleable iron frames with reinforcing ribs, drop forged heat treated hooks, special analysis hoist chains, precision etaoi to fit sheave sheave pocket to-

assuring somoth, free operation—lower hook mounted on ball thrust bearing for easy alignment of loaded chains to upper pocketed sheave and traveling of load.

It is a hoist of exceptionally few parts, therefore lighter in weight without sacrifice of any strength, and more portable.

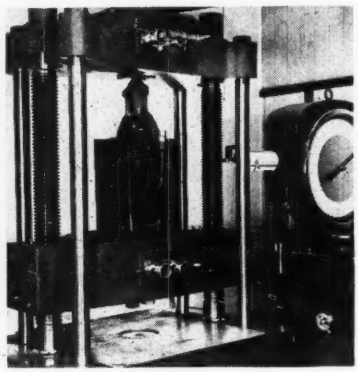
It holds its load at any point, will not self-lower—making it ideal for use by garages, small firms and for use on trucks. Made in ¼, ½, 1½ ton capacities.

B 1800F Thread Compound. Complete details on the new Fel-Pro "Hi-Temp" Thread Compound, that is said to prevent freezing and galling of metal surfaces at temperatures as high as 1800 F, is now being released by the Felt Products Mfg. Co.

The new C-5 "Hi-Temp" Compound was developed specifically for high temperature and high pressure applications, such as furnace tube header studs and plugs. The data sheet cites the case of a large utility company that experienced extreme difficulty in removing studs on the world's largest steam turbine. With the application of Fel-Pro "Hi-Temp," expensive stud breakage was completely eliminated. The company states that many petroleum companies, chemical plants, railroads and other industries where extreme operating temperatures and pressures are encountered, have tested and standardized on this thread compound.

A copy of the new data sheet, together with a sample can of the material, may be obtained from Felt Products Mfg. Co.

C High-Temperature Pipe Clamp. In the field of high-temperature piping it has been necessary to use clamps that were of special design and custom made. Grinnell Company, Inc. has undertaken to supply the demand for high-temperature pipe clamps in seven sizes from 4 in. through 16 in. with a commercial clamp made of chrome vanadium steel as a one-

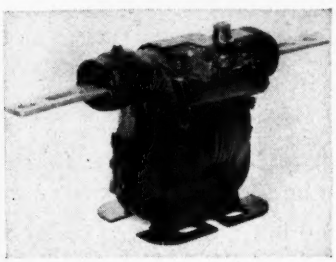


piece drop forging and equipped with a U Bolt of the same material. These are expected to meet the major portion of high-temperature pipe clamp requirements at temperatures up to 1000 F, without a high cost penalty.

Load ratings of the clamps for the various pipe sizes have been established after an exhaustive series of tensile strength tests (see illustration) in which the clamps were pulled to destruction to determine their ultimate breaking strengths. On the basis of the results of these tests conservative maximum recommended load ratings have been established for their use on piping at various elevated temperatures in accordance with the Code for Pressure Piping.

The accompanying illustration shows a 14 in. Fig. 224 pipe clamp set up in a tensile testing machine prior to being pulled to destruction at 66,300 lb load.

D All-Purpose Current Transformer. Designed for both relay and meter work, a new type CT-2.5 current transformer announced by Westinghouse Electric Corp. has class 0.3 accuracy with B-0.1, B-0.2, and B-0.5 burdens, the highest standard recognized by the American Standards Association (C-57) at price levels no higher than older type KO transformers suitable



only for relaying. Impulse strength has been increased in the new line to 45 kv as added protection against lightning and switching surges.

Available for indoor use in the 2.5 kv class of insulation for operation on circuits of 2890/5000 v or less, the transformer is produced in ratings from 10 to 800 amp with a full-load secondary current of 5 amp in all sizes.

The use of high-permeability Hipersil core steel in these transformers has made it possible to keep the size to a minimum while at the same time, accuracy and impulse strength have been improved markedly.

E Boiler Level Gage. The Jerguson Gage & Valve Co's Trulevel Gage is a boiler level gage which can be read and quickly checked at the remote reading point.

In checking, it is necessary only to turn the two checking valve handles on the cover of the gage in order to check the water level with complete accuracy, and in a matter of only seconds. This remote reading and checking of boiler water level is guaranteed correct because the gage is provided with a new type of datum

JANUARY, 1948

POWER GENERATION

53 W. Jackson Blvd.
Chicago 4, Illinois

Please have the manufacturers send me without obligation further information on the equipment indicated by the following letters:

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Please Print Clearly

Your Name.....

Your Title.....
Your Company Name.....

Company Address.....

City.....**State**.....
(If you prefer delivery at your home also fill in below)

Home Address.....

City.....**State**.....

Your Everyday Piping Needs Now Filled from Local Stocks

No waiting for most regular items at your Crane Branch or Wholesaler

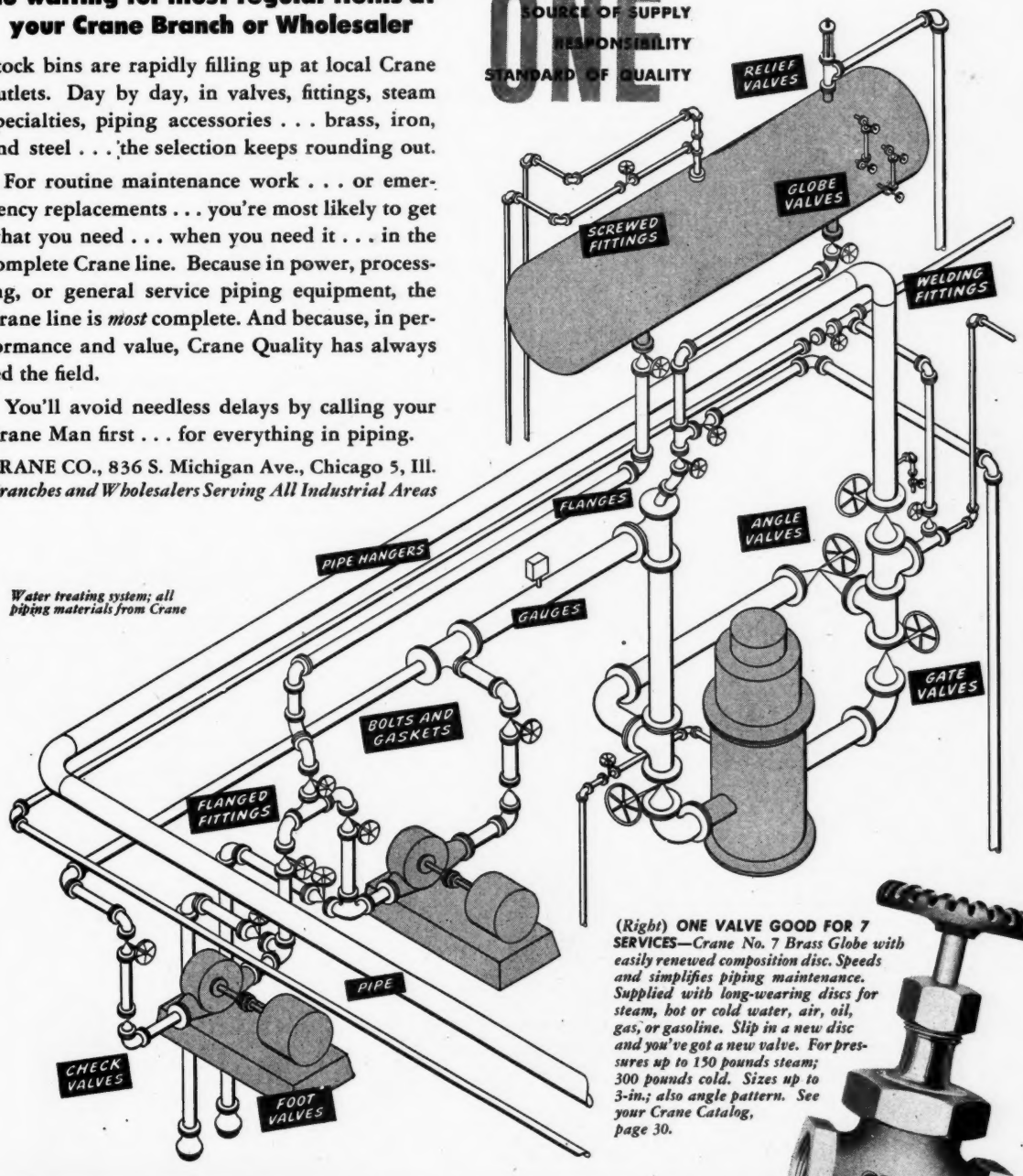
Stock bins are rapidly filling up at local Crane outlets. Day by day, in valves, fittings, steam specialties, piping accessories . . . brass, iron, and steel . . . the selection keeps rounding out.

For routine maintenance work . . . or emergency replacements . . . you're most likely to get what you need . . . when you need it . . . in the complete Crane line. Because in power, processing, or general service piping equipment, the Crane line is *most* complete. And because, in performance and value, Crane Quality has always led the field.

You'll avoid needless delays by calling your Crane Man first . . . for everything in piping.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

ONE
SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY



Water treating system; all piping materials from Crane

(*Right*) **ONE VALVE GOOD FOR 7 SERVICES**—*Crane No. 7 Brass Globe with easily renewed composition disc. Speeds and simplifies piping maintenance. Supplied with long-wearing discs for steam, hot or cold water, air, oil, gas, or gasoline. Slip in a new disc and you've got a new valve. For pressures up to 150 pounds steam; 300 pounds cold. Sizes up to 3-in.; also angle pattern. See your Crane Catalog, page 30.*

EVERYTHING FROM . . .

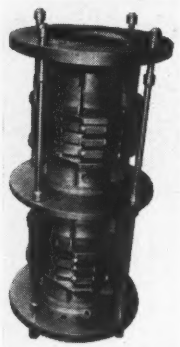
VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

column located at the drum. This datum column is fully steam jacketed, duplicating the temperature and specific gravity conditions existing in the boiler drum. As a result, dead sure accuracy of gage reading is assured, according to the Company's announcement.

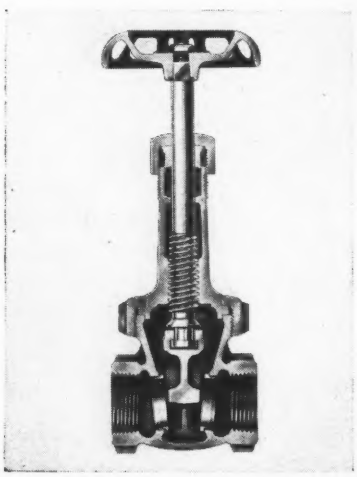
F Expansion Joints. Zallea Brothers & Johnson has announced production of a new line of universal expansion joints especially designed for use in refineries, power plants and chemical process plants. The expansion joint is capable of absorbing movement of high temperature lines in any direction—axially, laterally or angularly, or any combination of these.



Essentially, it consists of two corrugated elements linked together by a section of pipe. The amount of lateral movement here can be absorbed by the expansion joint depends on the length of pipe between the corrugated elements. The expansion elements can be either of unequalizing type for pressures or to 30 psi or self-equalizing for higher pressures.

Zallea Universal Expansion Joints are specifically designed to fit the requirements of each individual application and can be designed for all temperatures and pressures. Complete information can be obtained from Zallea Catalog 47.

G Bronze Gate Valve. A new bronze gate valve for 200 lb service has been recently designed. It is stated that this seating combination is of high tensile strength bronze wedge seating against monel metal seat rings of a hardness about 2½ times that of valve body bronze. They are available in sizes ¼ to 2 in. Seat rings are expanded into body and are equivalent to integral faces. It is designed so that the wear is taken by the most accessible and inexpensive part, the bronze wedge, which can be replaced by slipping it off the stem. Threads on the manganese bronze spindle are longer and larger in diameter, which is said to reduce wear to a minimum. It is designed especially for use in oil refineries, dye houses, food, rubber and chemical plants. Jenkins Bros.



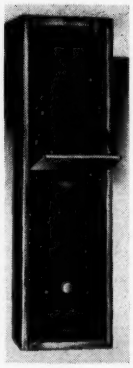
H Calculating Board. A new calculating board has been designed to give answers to electrical distribution problems in banked-secondary or industrial networks. It is made especially to assist engineers in determining currents and voltages in banked-secondary circuits supplied by csp transformers, but it has also been said that it can be used to give answers to problems found in industrial networks as well.

Circuits are set up on the board corresponding to the electrical constants of the actual system. Simulated transformers can be inserted at the proper points. Loads and short circuits are applied by inserting jumpers in plugs provided and turning the knobs to the proper positions. Then with the system duplicated in miniature, currents can be read on the built-in meters at any point on the system by plugging in test leads. Westinghouse Electric Corp.

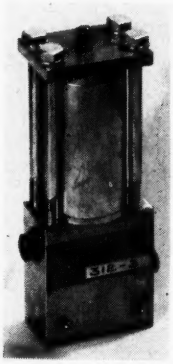
J Pressure Gage. A new version of a mechanical pressure gage, designed to measure up to 300 ft away, has recently been announced. It is stated that this gage indicates mechanical pressure in vises, chucks, presses, and mechanical assemblies, and shows tension in moving filaments, rods, etc.

Six ranges are supplied: 0-100 lb model, 3⅝ in. x 4 in. x 1¾ in.; 0-250, 0-500, 0-1000 lb models all 4-5/16 in. x 4 in. x 2-5/16 in.; 0-2500, 0-5000 lb models, 4⅝ in. x 4 in. x 2¾ in. Weights vary from 2¼ to 3½ lb. Repeater station cabinets are 8 in. x 11½ in. x 4½ in. with 6½ in. dial. System operates on 12 v d-c. W. C. Dillon & Co., Inc.

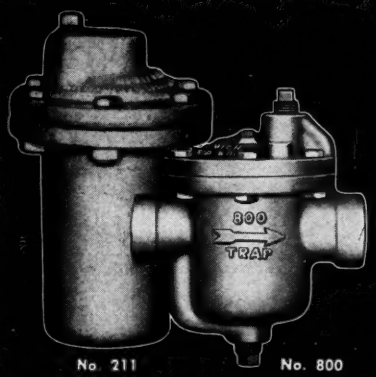
K Voltage Comparator. Production of the Arma alternating Voltage Comparator for commercial use has been recently announced. It is stated that the range of application of this comparator includes the measurement of vectorial ratios essential to computer development, transformation ratio of transformers and networks, power factor of transformers, power factor and Q of resistors, capacitors and inductors capacitance or inductance by reference to a suitable standard ratio of two currents, and power factor of a-c machines. It is designed to function at any frequency between 50 and 1,250 c per sec and can be used in research laboratories, power companies, and manufacturers of electro-mechanical and electronic equipment. Arma Corp.



L Solenoid Valve. A new solenoid valve has been recently perfected. It is designed to be a compactly-built unit for all hydraulic systems, or for the handling of any non-corrosive fluids. It has a maximum working pressure of 3000 psi, and electrical requirements of 6, 12, 24, or 36 v d-c, with low current consumption of 2.3 amp at 12 v. It is said to lock the fluid in one direction and to admit free flowing in the other direction. Waterman Engineering Co.



M Combination Wire-Stripper and Wire-Cutter. A new pocket-size, combination wire stripper and wire cutter, covering the wide range of wire sizes from 22 to 10, has been announced recently. It has distinctively colored, shockproof yellow plastic handles, and incorporporates a built-in wire cutter, serrated plier jaws, a handy stud size gage and accurate sized stripping notches to serve as a convenient wire size gage. The retail price is $2.95. Aircraft-Marine Products, Inc.



No. 211 No. 800

Above left — Armstrong bottom inlet—top outlet series trap.

Above right — Armstrong No. 800 side inlet—side outlet trap.

PROOF THAT ARMSTRONG TRAPS PAY DIVIDENDS:

½ TON COAL SAVED daily at American Snuff Co., Clarksville, Tenn., with 12 No. 813 traps on tobacco drying kiln. Also ½ hour faster heating up.

●

15% FUEL SAVING, 62% less maintenance with Armstrong Traps at Grove City Floral Co., Grove City, Pa.

●

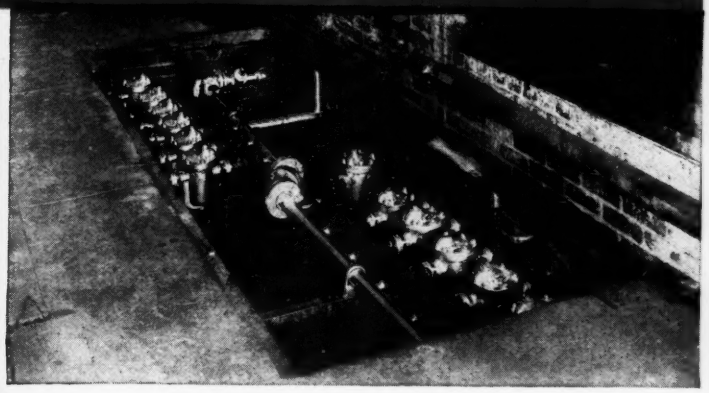
30% LESS fuel consumption, 69% LESS water consumption, and more extraction of oil from material being crushed, after use of Armstrong traps.—Pacific Nut Oil Company, Los Angeles.

●

ONE BOILER INSTEAD OF TWO used after installing Armstrong traps. Also 30-ton-per-month saving in fuel.—Daniel Bond and Co., Buenos Aires, Argentina.

For Fuel Savings and Maximum Production

SELECT THE CORRECT STEAM TRAP FOR THE JOB!



In order to maintain high temperatures, high production and minimum fuel consumption it is essential that steam traps be correctly selected for each piece of equipment in your plant. Don't select traps by pipe sizes alone. Here's a convenient check list for proper trap selection:*

1. DOES THE TRAP HAVE ADEQUATE CAPACITY FOR PEAK LOADS? Traps should have the capacity to take care of the above normal condensate loads encountered in starting up cold equipment. This will often save hours of warming-up time and greatly increase production.

2. DOES THE TRAP *ACTUALLY* HAVE THE CAPACITY CLAIMED FOR IT? It is possible to unknowingly buy a trap with insufficient capacity. This limits production and wastes fuel. Armstrong trap capacities are very conservatively based on *actual* tests with hot condensate, and a liberal safety factor is recommended. If you follow Armstrong recommendations the traps will handle any condensate load that will be encountered.

3. IS THE TRAP SUITABLE FOR THE PRESSURE? A trap won't work satisfactorily at a steam pressure above that for which it is designed. (In switching traps from one location to another, be sure they are not put on a line with a pressure above their rating.)

4. DOES THE TRAP HAVE ADEQUATE AIR-HANDLING CAPACITY? Air (always present in steam) reduces heat transfer efficiency, lowers temperatures and slows up production. Armstrong traps discharge all normal amounts of air along with condensate.

5. DOES THE BODY STYLE PERMIT THE MOST EFFICIENT INSTALLATION? Correct installation, essential to efficient trap performance, is simplified and reduced in cost by the choice of Armstrong trap body styles: No. 800 Series side inlet—side outlet; No. 801 Series side inlet—bottom outlet, and No. 200 Series bottom inlet—top outlet.

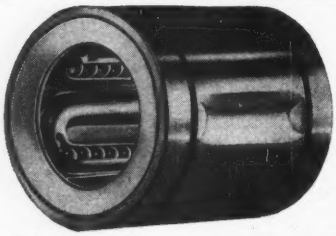
*The 36-page ARMSTRONG STEAM TRAP BOOK gives complete data on trap selection and installation on all classes of equipment. Send for your copy. ARMSTRONG MACHINE WORKS, 810 Maple Street, Three Rivers, Mich.

ARMSTRONG "INVERTED BUCKET" STEAM TRAP

ARMSTRONG *Inverted Bucket* STEAM TRAPS

No. 2 of a series of advertisements devoted to improving efficiency through better trapping.

N Linear Ball Bearing. Production of a new type unlimited travel anti-friction ball bearing for linear or reciprocating motion has been announced. The new bearings have been designed for high speed, low cost production. The bearing is a complete self-contained unit



and has only three basic parts in addition to the balls. They are presently available for shafts having ¼, ½, ¾ and 1 in. diameter. The new bearing is said to have an extremely low friction coefficient designed to prevent cooking and binding. Its free rolling action is meant to maintain precision alignment by elimination of wear. Thomson Industries, Inc.

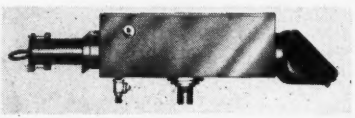
O Alternator. Redesigned three and four circuit alternators, which are said to eliminate the necessity to "phase out" the pilot circuit of the devices being controlled,

have been recently announced. This Type HR alternator is an integral part of the company's alternating float switches of the Types HSB and HSC. Automatic Control Co.

P Automatic Motor Starter. The development of a new automaticmotor starter has been recently announced. These starters are of the non-reversing auto-

transformer type designed for use with single speed, two or three phase, squirrel cage induction motor driving pumps, fans, M-G sets, compressors and other equipments. They are available in standard sizes for use with squirrel cage induction motors up to and including 100 hp, 550 v, 60 c. They are said to be advantageously used where inrush starting currents must be reduced or where motor starting torque requires adjustment. The drip-proof enclosed starter is arranged in three removable sections—the contactor panel, the timer panel and the multi-tap autotransformer, providing complete accessibility to individual components it is reported. For ease and simplification of installation all line, load and control terminals are completely accessible. Ward Leonard Electric Co.

Q Turbidity Recorder. A new turbidity recorder has been announced. These instruments can be used to measure various undissolved substances or emulsions present in solutions, and can be applied to boiler feed water, water clarity problems, oils and solvents, and various fluids. They are avail-

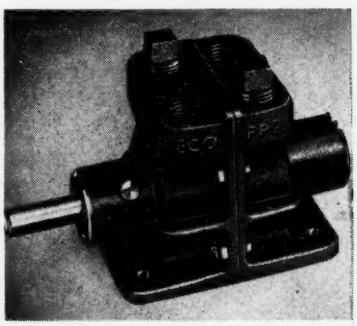


able in range of 0 to 3 ppm, 0 to 50 ppm, 100 ppm, and up. The new instruments comprise a viewing chamber through which the solution to be measured is passed, and attached to one end is a light source and the other a photo relay unit. Ess Instrument Co.

R Soap Dispenser. A new all-plastic soap dispenser is now available. It is made of shock-resistant amber plastic. It is designed so as to withstand repeated hammer blows, and reveals at a glance the level of the contents. It is protected by a lock on the top, and is said to operate with any brand of powdered soap. The dispenser is priced at $3.00.

The same company offering the dispenser also offers a new hand cleanser in powdered form made to remove dirt, grease, oil, tar, paint, and grime of all kinds without injury to the hands. It contains no sand, pumice or harsh abrasives, and is especially prepared for combating industrial dermatitis. It is available in 5 lb packages or 100 and 300 lb drums, and will dispense from any standard powdered soap dispenser. L. E. Hicks & Son, Inc.

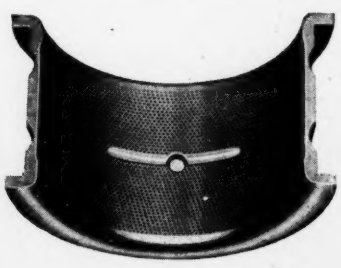
S Gearless Pumps. A new line of gearless pumps for general industrial use has been recently announced. These pumps are designed so that they can be adapted for nearly every type of liquid handling including acids, solvents, oils, etc. They are available in ¼ and ⅛ in. sizes, capacities from 1 to 12 gpm varying with pump speeds and pressures. It is stated that the pumps can be used against pressures up to



50 psi, and can be run and will deliver from 200 to 3500 rpm.

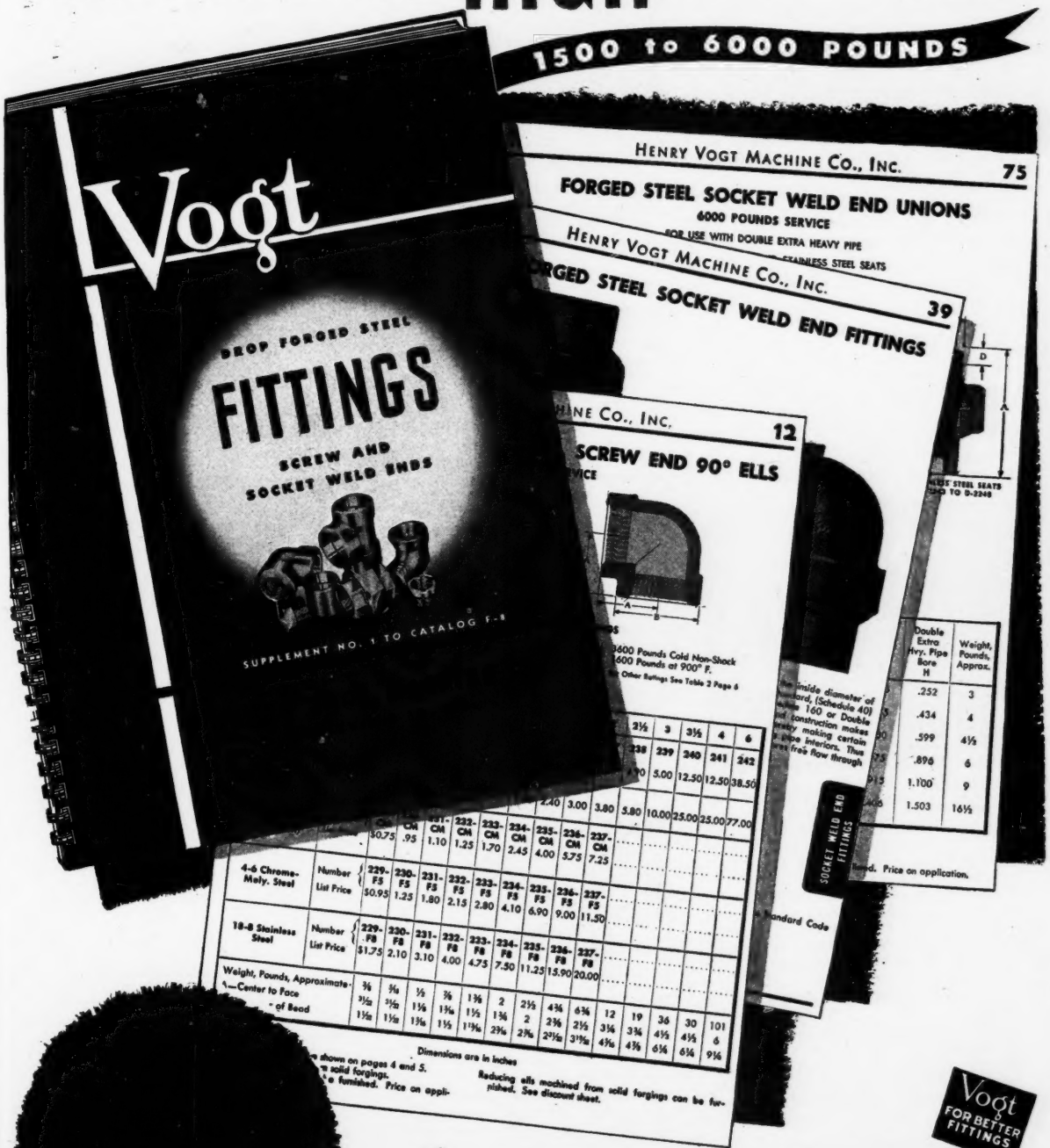
A special feature of these new pumps is their new double impeller design which is said to give a strong flow against pressure, and can be adapted to the operation involved. Bodies are available in stainless steel, monel and bronze. Eco Engineering Co.

T Gridded Bearings. A new method to precision-build gridded bearings has been recently announced. Present applications of gridded bearings are main and connecting rods of heavily-loaded Diesel engines and similar heavy-duty service. These bearings are said to be operating under loads of over 3,500 psi projected area, with shafts as low as 160 Brinell hardness; minimum depth of grids being 0.008 in.; and the minimum area of babbitt is stated to be 40 per cent. The required balance of conformability and embedability for individual applications is said to be obtained by controlling



FIRST CHOICE FOR HIGH PRESSURE PIPING SYSTEMS

1500 to 6000 POUNDS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DROP FORGED STEEL
FITTINGS
SCREW AND SOCKET WELD ENDS
SUPPLEMENT NO. 1 TO CATALOG F-8
HENRY VOGT MACHINE CO., INC. 75
FORGED STEEL SOCKET WELD END UNIONS
6000 POUNDS SERVICE
FOR USE WITH DOUBLE EXTRA HEAVY PIPE
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NEW

This new 80 page Catalog gives complete information on carbon steel and alloy steel Fittings in sizes from 1/8" to 6", with pressures from 1500 lbs. to 6000 lbs., for oil, steam, water, air, or gas services. Alphabetical, Numerical and Pressure Indexes are designed to help users quickly find specific data.

HENRY VOGT MACHINE CO. • 1000 W. Ormsby St., Louisville 10, Ky.
Branch Offices: New York, Philadelphia, Cleveland, Chicago, St. Louis, Dallas

the proportion of land (the parent bronze) and the babbitt-filled grid.

These grodded barings are customarily made as half bushings, but can be furnished as full cylindrical bearings if desired.

These bearings are designed to overcome objections to using bronze with a shaft that is not hardened, because the gridded bearing is "self-healing." In periods of great overstress, some of the babbitt is said to melt out of the grids and forms a running surface that prevents seizure. The babbitted grids are so designed that they will not seize and thus they provide a safety factor that prevents damage to the shaft. To increase further the seizure resistance and corrosion resistance of gridded bearings, a 0.002 in. run-in surface of lead-tin is electroplated in the bore. National Bearing Div., American Brake Shoe Co.

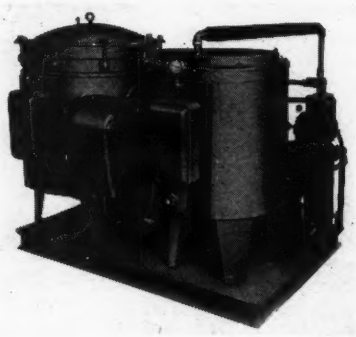
U Amplifier. A new instrument, which is designed to measure and amplify minute power impulses as low as 0.2 micro v, has been recently announced. Power inputs from ironization, photo-electric cells, thermo-couples, or wheatstone bridge are said to be amplified by means of an electro-mechanical bal-

ance, giving an output signal directly proportional to the input signal. The amplifier has an isolated input circuit which is insulated from the output and ground. Input is measured and output stabilized through a feedback circuit. The instrument incorporates a mechanical zero adjustment with sufficient range designed to permit operation from various reference voltages. It also is said to include an adjustable gain, no lower frequency limit, and low input resistance.

The manufacturer states that no extended warm-up period is required; standard tubes to commercial tolerances are used; and no tube matching is needed. Manning, Maxwell & Moore, Inc.

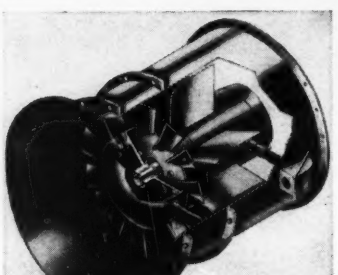
V Oil-Conditioner. A new oil-conditioner has been recently announced. It is a portable, self-contained unit for purification of transformer, circuit breaker, cable, refrigerator, vacuum pump, turbine and other oils. It is designed to remove air, volatile organic acids, fuel dilution, undissolved gasses and free or emulsified water as well as insoluble contamination. It is available in capacities up to 600 gph.

The oil-conditioner is described as a combination vaporizer and cartridge filter, mounted on a common base and arranged to afford operation of the filter and vaporizer independently or together as application



warrants. Filters and vaporizers are available separately as complete units in a wide range of sizes. The cartridge filter is designed for the removal from oil of all insoluble contamination. It is being offered in two types. One uses 11 by 18 in. cartridges, and may be had in 1, 2, 3, 4, 6, and 8 cartridge units. The other type uses 7 by 18 in. cartridges in multiples of 1, 2, 4, 7, 9, 14 and 18. Various size vaporizers, from 50 to 600 gph capacity, are available. U. S. Hoffman Machinery Corp.

W Adjustable-Blade Fans. A new line of adjustable-blade fans for heating, ventilating and air conditioning requirements in industrial establishments has been announced. The new series consists of axial-flow fans of the vaneaxial type designed for a range of pres-



sures up to 9.60 water gage and volumes up to 100,000 cfm. They are available in 124 different models, from various combinations of 15 different housing diameters (18 to 60 in.), 4 hub sizes, 16 motor-frame sizes, and 4 different speeds. Adjustable blades insure flexibility in performance. Joy Manufacturing Co.

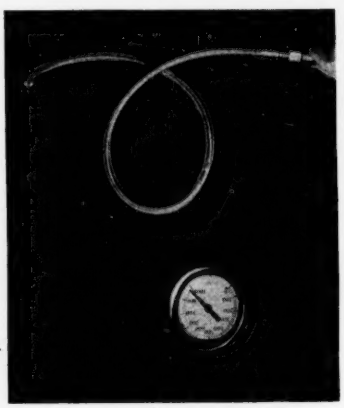
X Gas Welding Rod. Deposits of beryllium copper followed by heat treating or cold working are no longer required to produce maximum overlay hardness on copper, where hardness is the sole requirement, according to an announcement by the manufacturer of a new gas welding rod known as "EutecRod 188," having a maximum hardness up to 67 Rc.

Special applications include bearings, gears, marker teeth, as well as centrifugal pumps, chemical processing components, globe or gate valves, oil-jet nozzels, and other machinery where corrosion-resistance is important.

Microphotographs show that an overlay produced on copper by the new gas alloy welding rod has a Rockwell hardness of 67, which is produced in a single pass without dilution.

The new alloy has a bonding temperature of 1800 F, and remelts at 1950 F. It is stated that in addition to producing extreme overlay hardness on copper, the new alloy applies equally well to steel and ferrous metals generally, without dilution with the base metal during the welding process, and is characterized by high resistance to corrosion, including nitric, acetic, phosphoric, tartaric, and citric acids. Eutectic Welding Alloys Corp.

Y Flexible Tubing. A new type of flexible tubing has been recently announced. It is described by the manufacturer as having the flexibility of rubber and the sturdi-



ness of steel, able to withstand pressures of 980 psi without bursting, leakage, or damage, and to provide free-flowing transmission of air, water, gases, oil and volatiles.

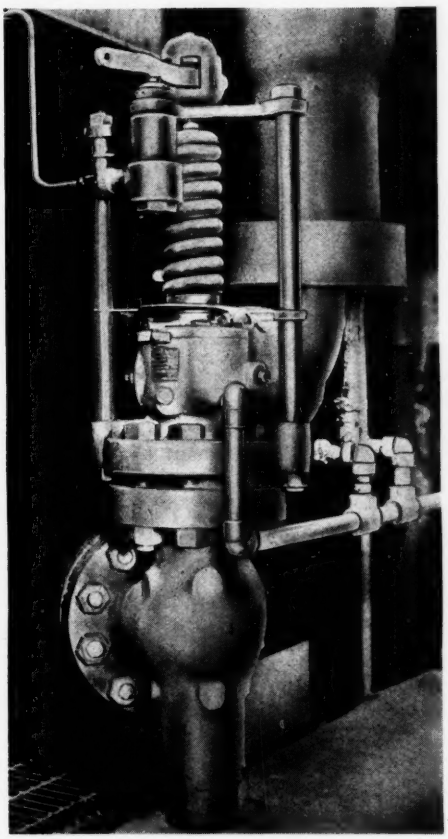
It consists of a tough rubber tubing protected by steel wire braid cover. The tubing is a specially compounded synthetic rubber, while braiding may be either galvanized or stainless steel, aluminum, or bronze depending upon specific service conditions. It is available with snap-on couplings connected and disconnected in one easy operation. The coupling is made of aluminum to resist rust, corrosion and heavy wear from frequent operation. Penflex Sales Co.

Z Locking Terminal Block. A new terminal block has been recently developed for the electrical industry. This block is provided with solder-type spade lugs which are recessed into the body of the device. When the binder screws are tightened, each lug is held rigidly in place against a shoulder of the plastic material forming the terminal block.

Terminals cannot pull out or drop out, but any terminal can be easily

Give Your Boilers a Break!

End Safety Valve Troubles by Installing FOSTER 38-SV Safety Valves with these 5 GUARANTEED ADVANTAGES:



Hundreds of Foster 38-SV Safety Valves are giving top performance in important installations. This 2½" superheater unloading valve operates at 1450 lb., 950° total temp. Others are in service up to 2575 lb. at 1000° F.

1 Built to Stay on the Job—the Foster 38-SV is the SAFETY valve that is built to pop without causing boiler outages. On accelerated tests in an Eastern Utility, one of these valves has been popped every day for more than 6 years. It has had only routine maintenance, and yet it pops consistently at set pressure, and does not leak. In the Chief Engineer's own words—this is the equivalent of at least 40 years' normal service.

2 Accurate Popping—Once set at the desired popping point, the Foster 38-SV pops on the button for each successive pop. For instance, in another Utility installation, the 38-SV under test was set for 600 lb. and popped 50 times in quick succession. The first pop was at 600 lb. and the 50th pop was at 595 lb. In spite of the heat of this abnormal operation, the Foster 38-SV was thrown off less than 1%. After a short cooling period, it again popped at 600 lb. That's test gauge accuracy!

3 Minimum Blow-down—Foster 38-SV's are adjustable so they can be set to reseat when pressure has dropped as little as 1% below the popping point. In this same test the 38-SV, on its first pop, reseated at 594 lb. for a 6 lb. or 1% blow-down. On the 50th pop, it reseated at 589 lb. which is also 6 lb. or 1%. After each pop, it reseated positively with no chattering or leakage. Only over-pressure up the stack—no useful steam wasted.

4 High Relief Capacity—Foster 38-SV's have larger bore because they can handle larger volume of steam and still control blow-down. Depending on operating conditions, they may give more than twice the capacity of other makes, as in the case of 5 Foster 38-SV's required to replace 12 "conventional" safety valves of the same nominal size. Fewer valves to buy—fewer valves to service.

5 Low Maintenance—Hot or cold, the piston in the 38-SV fits loosely and cannot stick, and yet no steam reaches the spring. The spring stays cool enough to touch, even while the valve is popping—which means longer spring life. Disc and seat expand at the same rate during heating-cooling cycles—there is no drag to destroy seating surfaces. Simmering and chattering have been eliminated as a source of destruction. Discs will not warp or crack. When routine inspection and maintenance are indicated, complete loading assembly lifts out without disturbing the spring setting.

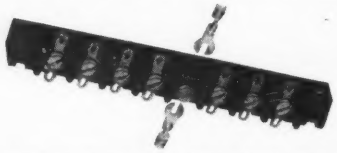
For full details on the design and construction features that enable this valve to outperform any other safety valve, get in touch with your Foster Representative or with us direct.

FOSTER ENGINEERING Company

PRESSURE REGULATORS...RELIEF AND BACK PRESSURE VALVES...AUTOMATIC STOP AND CHECK VALVES...ALTITUDE VALVES...DAMPER REGULATORS...FAN ENGINE REGULATORS...PUMP GOVERNORS...TEMPERATURE REGULATORS...LIQUID LEVEL CONTROLLERS...FLOAT AND LEVER BALANCED VALVES...NON-RETURN AND TRIPLE DUTY VALVES...VACUUM REGULATORS OR BREAKERS...SIGHT FLOW BOXES...STRAINERS...SAFETY VALVES...SIRENS

111 MONROE STREET • NEWARK, N. J.

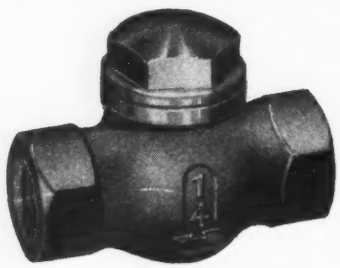
removed from this block or replaced by loosening the binder screw and lifting the lug out of its "lock-in" position. The screws are insulated to the ground, as the base of the



phenolic block is absolutely solid. The terminal "lock-in" arrangement is designed to eliminate the danger of spade lugs pulling out.

This block is factory assembled in any desired number of terminals from 1 to 18. Curtis Development & Manufacturing Co.

AA Spring Check Valve. This new spring check valve is designed for use on air compressors, gas pumps, water, air, oil, or gas lines. Piston operated and spring-



loaded, this new valve is reported to operate with a minimum of noise while providing a positive non-leaking check to water, air, oil, or gas including butane and propane.

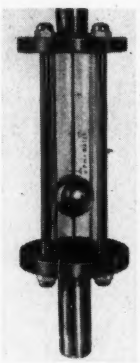
This series 1000 valves are cast from high grade brone. The valves are available in ⅛, ¼, ⅜, ½ and ¾ in. ips screwed ends. Pokorney Manufacturing Co.

BB Steam Trap. The design of these inverted bucket steam traps has been improved so that the company is now using stainless steel precision castings made by the "lost wax" process for the interior parts. This is done to help prolong the life of the traps.

The cover plate is mounted at a convenient angle with the body and carries the entire working mechanism of the trap. It can easily be removed from the trap body without breaking any pipe connection. The bucket and lever with valve is suspended from the cover through a fulcrum plate which serves also as the valve seat retainer. An outstand-

ing feature of this trap is said to be positive alignment of the valve with respect to the valve seat. This is accomplished through the dual purpose "fulcrum and valve retaining plate." O. C. Keckley Co.

CC Ball Flow Indicator. A new ball flow indicator, providing both a visual indication of flow and an approximate rate of flow, has been announced.



The unit consists of a tapered glass tube with a moving, guided brass ball which acts as the flow indicator. Movement of the ball is confined to the center of the tube by a slender stainless steel rod. Neoprene gaskets are used to seal the glass tube, allowing the ball flow indicator to be used with lubricating oils and many solvents.

The indicator is manufactured in all standard pipe sizes from ¼ to 2 in. for flow ranges from 0.2 to 60 gpm. A pipe nipple is supplied for ease in handling with a pipe wrench when the indicator is connected to other fittings. These indicators may be connected in series with pumps, filters, water treating equipment, bearings and cooling or heating jackets to show progressive wear or clogging of equipment. Schutte & Koerting Co.

DD Space Heater. A new multi-purpose, all-electric space heater has been announced. It is designed to supply fan-forced warm air, directed into the working zone, in less than a minute after being turned on. The heater can be used as a portable unit, plugged in and operated manually wherever heat is needed or as a permanently mounted ceiling or wall suspension unit.

Safety and durability are said to be achieved with patented heating element which has no exposed hot wires or glowing coils. It consists of an insulated nichrome resistor wire, sheathed in metal and embedded in a one-piece finned aluminum casting. This casting dissipates heat rapidly, giving high Btu output at low operating temperature. A thermal cut-out is said to prevent overheating. Thus, the manufacturer states, it can be used in spray rooms, paint shops, and where inflammables are stored.

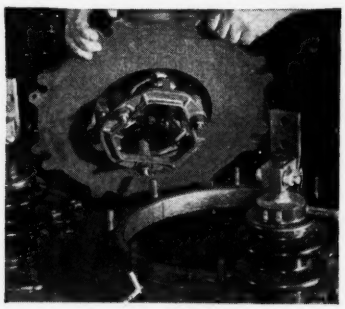
The heaters are available in capacities of 1.5 and 7.5 kw. Electromode Corp.

EE Mechanical Relief. A cover-mounted, mechanical relief device has been designed to vent internal transformer pressures caused by electric arcs or overloads more quickly and effectively than is possible by any present device that depends upon the rupturing of a diaphragm. It is made to fit any transformer with a 9 in. handhole opening, but can be used for larger openings if necessary.

The new relief device will withstand full vacuum when filling the transformer with oil under vacuum on tanks designed for this method of filling. A locking method is also available so that the tank can be pressure tested in the factory or in the field.

The mechanical relief device is 17 in. in diameter and stands approximately 7 in. above the transformer cover.

A roller latching arrangement locks the vent tightly closed until the pressure for which the device is set is reached when it trips the vent



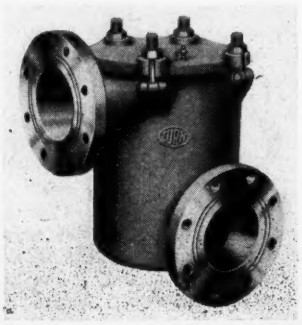
fully open. The device can be set for 10 psi, and tripping takes place within ½ lb pressure of this setting. A dome over the opening prevents rain from entering the transformer even after operations.

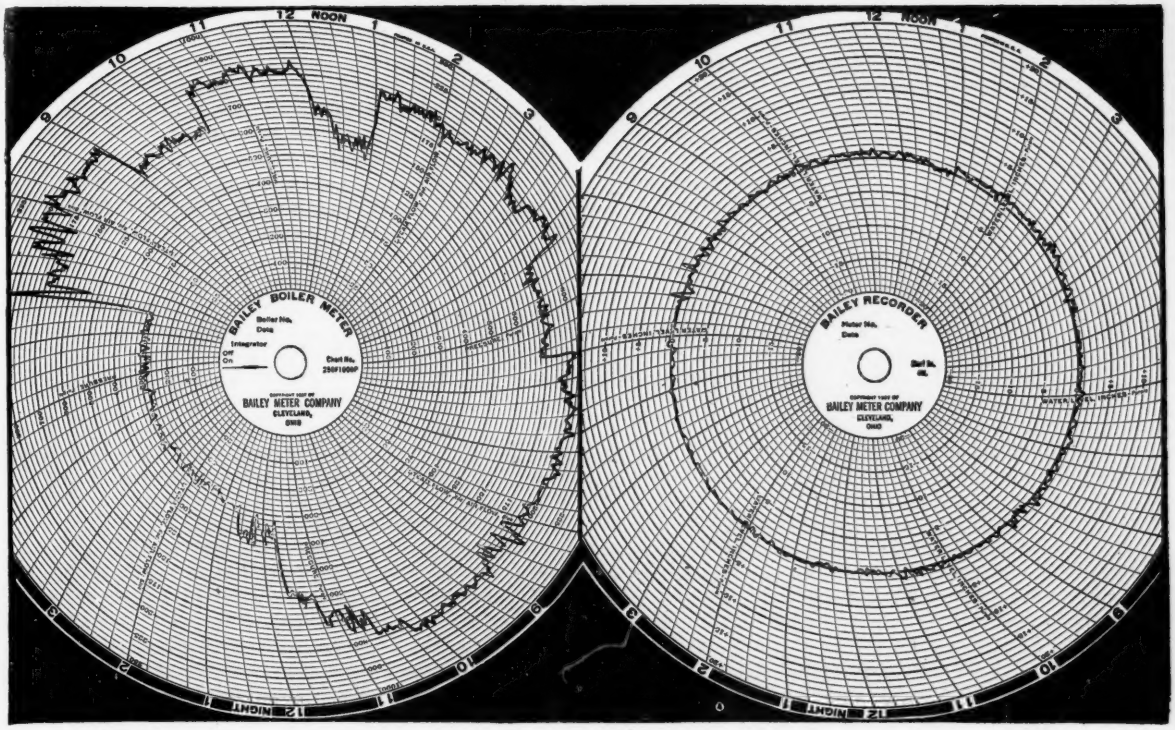
The manufacturer says that the new relief device offers less resistance to escaping gasses than diaphragm types of relief devices and, in consequence, pressures within the transformer do not build up to excessive values nor is oil vapor thrown as far when operating. Westinghouse Electric Corp.

FF Offset Strainer. An offset strainer has been developed to permit the strainer to be completely drained as the line itself is drained. With the inlet and outlet at right angles, the unit can be installed to form a right angle connection in a piping system.

The basket and basket chamber can be made to any length, depending upon the amount of entrainment in the stream. A cleanout plug is furnished to permit steam blowdown cleaning when practical.

The strainers are made in cast bronze, steel, semi-steel, iron, or alloyed metals for corrosion resistance. Types are available for working pressures from 125 to 300 psi in sizes from 1½ to 12 in., with flanged, screwed, or welding connections. J. A. Zurn Mfg. Co.





COPES FLOWMATIC CONTROL
for a 1265-psi, 900-F, C-E Boiler

Over a load range of 110,000 pounds per hour, the water level in this 1265-psi, 900-F Combustion Engineering three-drum boiler is stabilized within plus-or-minus one-half inch by COPES Flowmatic.

The charts tell the story. They were recorded five years after the two-element COPES Flowmatic assumed fully-automatic control of feed input and water level for this high-duty steam generator.

During those five years, no more than routine inspection and care by the boiler-room personnel was needed to keep the COPES operating at peak efficiency. Flowmatic control is dependable.

A performance report on this utility installation is given in 8-page Bulletin 465. There are cross-sections of plant and boiler, photographs of equipment, and charts showing water level control under conditions of constant load, variable loads and emergency operation. Write—your letterhead, please—for a copy of this informative report.

NORTHERN EQUIPMENT COMPANY
182 GROVE DRIVE, ERIE, PENNSYLVANIA
Feed Water Regulators, Pump Governors, Differential Valves, Liquid Level Controls, Reducing Valves and Desuperheaters
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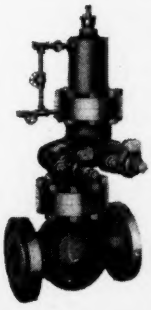
★ GET CLOSER LEVEL CONTROL WITH COPES FLOWMATIC

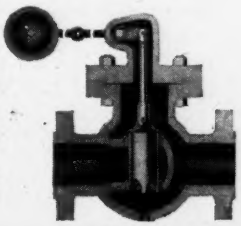


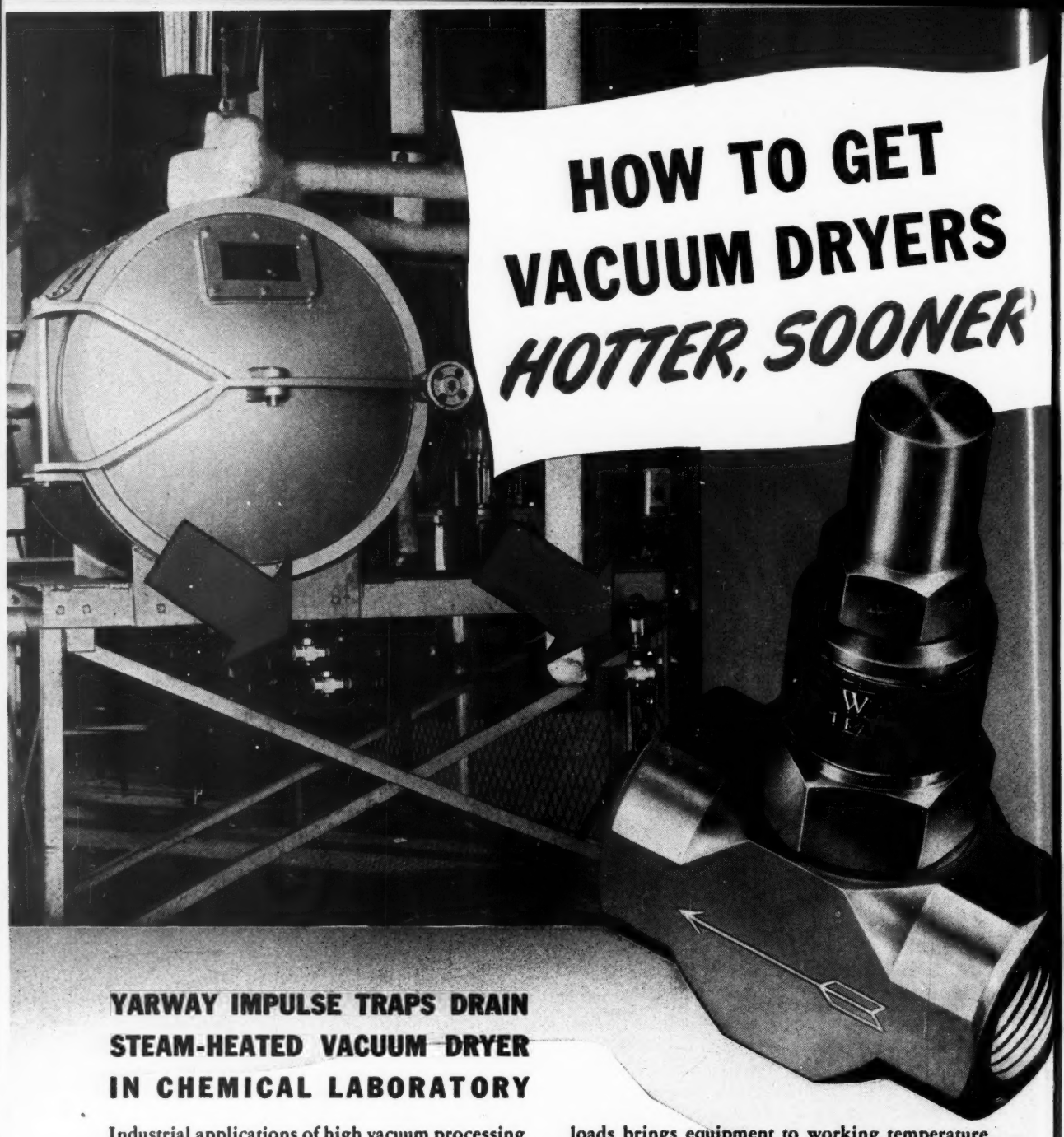
PUMP GOVERNORS

In most installations, especially where the load conditions do not warrant COPES Flowmatic control, good feed water regulation should begin at the boiler feed pumps. *Dependable* excess water pressure control for your feed system, no matter how simple or how demanding your needs, can be provided by COPES engineers. Write—outlining your operating conditions in detail—for their helpful recommendations.

BALANCED CONTROL VALVES

Many plants have found real savings by paying a few dollars more for COPES Balanced Valves for controlling make-up water to feed water heaters, level in open tanks, evaporator flows and other uses. Control is more accurate with the scientifically-balanced, practically-frictionless COPES. Rugged construction assures long service life.





HOW TO GET VACUUM DRYERS HOTTER, SOONER

YARWAY IMPULSE TRAPS DRAIN STEAM-HEATED VACUUM DRYER IN CHEMICAL LABORATORY

Industrial applications of high vacuum processing are constantly increasing . . . and so are installations of Yarway Impulse Steam Traps.

Here at the Eastern Regional Research Laboratory of the Department of Agriculture, three Yarways are shown on a steam-heated vacuum drum dryer in the Chemical Engineering and Development Division.

These and nearly 200 other Yarways used on various equipment in the laboratory, are doing a good job . . . and so they should. Yarways are famous for *getting equipment hotter, sooner, and keeping it hot. Continuous* discharge under heavy loads brings equipment to working temperature *sooner;* discharge at *short intervals* under lighter condensate loads *keeps it hot.*

Other Yarway features—one moving part, easy maintenance, small size, easy to install, suitable for all pressures, low price.

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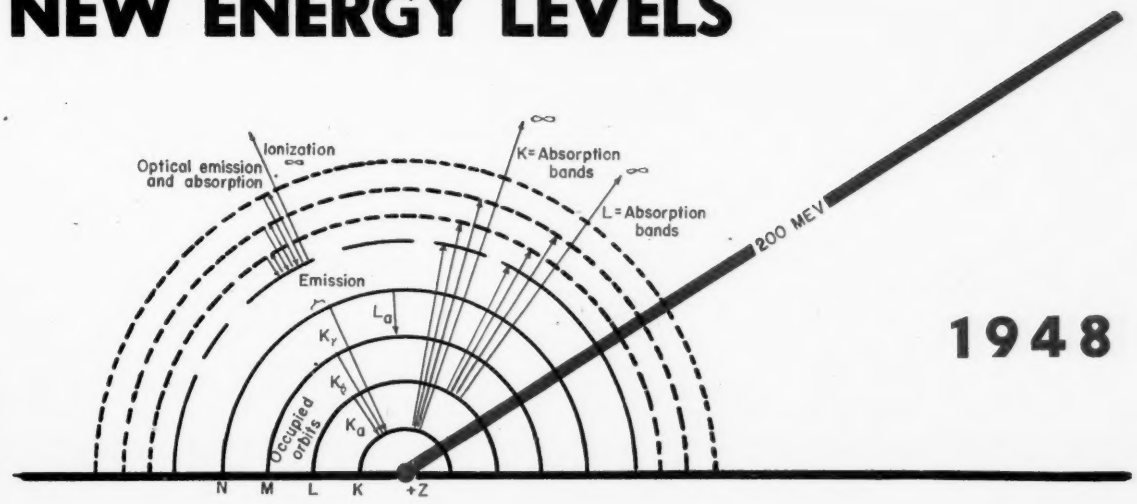
YARWAY IMPULSE STEAM TRAP

NEW ENERGY LEVELS



IN THE HOUR before dawn one day in the summer of 1945, the hills of the Jornado del Muerto, a desert stretch of New Mexico, were briefly lighted with a light no man had ever seen before. It was the unearthly, seering brilliance of an energy release so vast that even the light of the sun paled into insignificance by comparison. Nothing man had ever done before could be compared to what he accomplished in that instant, for in that instant he had unlocked the deepest mystery of the universe.

Yet no new great principle of nature was discovered or revealed in that first atomic explosion. The bomb tested at Alamagordo was based on the broad foundation of a century of physical science. Its design embodied the great principles of the behavior of radiation and matter as they were worked out in the closing years of the last century and in the first three decades of this century. If there was any surprise among those who witnessed this first explosion, it lay not in any new great discovery. It lay rather in the fact that what happened was so like what they thought would happen—that the physical science which had been built into this new weapon was such a reliable guide.

Despite the atomic bomb, only few people in the world understand the true significance of atomic energy. Few realize that in that brief instant at Alamagordo, man attained a new energy level, one so far above any he had ever reached before that its implications are almost beyond belief. Human civilization is about one million years old. In that time it has developed from the level of our prehuman ancestors to the status in which we find it today, a civilization based on the use of power from chemical energy.

All living organisms require energy. In order to maintain their existence, organisms must be able to control and utilize energy in one form or another. In the human species, culture is the characteristic means of harnessing energy and of putting it to the service of man's needs. Early man had only his own muscular energy—about 1/10 horsepower per adult male. Later he utilized the muscular energy of animals and to some extent the power of the wind and water. It was not until the invention of gunpowder that he began to use the power of expanding gases. This, in time, led to the development and use of the steam engine, which enormously increased the energy level on which he could operate. Our grandfathers had available less than 1 hp per capita; today, the world has 25 to 100 hp per capita in its various countries and localities.

Most of this power is derived from the chemical energy of our liquid and solid fuels, an energy which in coal amounts to some 13,000 Btu per lb. To produce these 13,000 Btu per lb, a pound of coal containing 230 times 10^{23} atoms gives off energy at the rate of 4 electron volts per atom as it burns.

In the nuclear reaction, uranium also gives off energy, atom by atom. But note this; in the fission of uranium, each atom gives off not 4 electron volts, but 200 million electron volts! Thus in the fission of uranium we release 50 million times as much heat per reacting atom as does coal in ordinary combustion. This works out to be 3 million times as much heat per pound.

Pound for pound, therefore, we have reached an energy level 3 million times greater than anything we had before July 16, 1945. What this new energy level will mean to future civilization even our most fertile imaginations cannot foretell. The great social changes inaugurated by the technological revolution powered by coal and oil have not yet run their course but, now, in atomic energy man has at last harnessed a force so great that nothing we have done with power in the past can serve as a criterion for what may happen in the future. The vital question today is not, will atomic energy be used but how will it be used. It brings us once again to the two sides of man's struggle for existence. On the one hand, he is struggling with the forces of nature, trying to subdue them and bend them to his use; on the other, he is struggling with his fellow men for the possession of the resources of nature. Perhaps in atomic energy he has at last found a resource which will require no further struggle—there is probably enough for all. If atomic energy is a threat to man's existence as a civilized being, it also offers a promice of peace and abundance in the ages to follow.—A. W. K.

The Electric Pow

Fig. 1. Control room in the central load dispatching station of Arkansas Power & Light Co. at Pine Bluff, Arkansas. This is the nerve center of a 3 state power system developed by the late Harvey Couch. From here are controlled the interconnected systems of Arkansas Light & Power Co., Louisiana Power & Light Co., Mississippi Power & Light Co., and the New Orleans Public Service, Inc. Carrier current is used for voice communication over the power lines
Legnier and Reynolds, photo

AT THE BEGINNING of the year 1948, despite the vast power productive capacity of the United States, the country finds itself with less reserve electric generating capacity than at any time since the electric power era began.

At the close of the year the installed generating capacity in public utility stations was approximately 52 million kilowatts. The peak load was about 49 million kilowatts. Thus, we had a reserve of only 3 million kilowatts—about 6 per cent. This is less than a third of the reserve which has normally been carried.

At the same time the demand for electricity continues to grow at an astonishing rate. During November, the weekly electrical output of the public utility systems of the country rose to over 5 billion kilowatt hours and the expectations were that this high value would be exceeded by a considerable margin before the year's end.

This high and sustained rate of growth of demand for electric service is the most notable feature of the electric power business. It continues at an astonishing rate and future potentialities of this service still appear to be enormous.

Of immediate concern, however, is the narrowing margin of reserve generating capacity — the fact that the load seems to be increasing at a faster rate than new generating capacity. While at this writing there is still a bare 3 million kilowatts of reserve for the nation as a whole, in a number of areas it is less than the 5 or 6 per cent national average. In some regions it is down practically to zero, and emergency steps are being taken to handle the load in case of failure. Almost everywhere, system operators occupy uncomfortable positions. In some areas emergency measures have been taken, but so far for the nation as a whole, no curtailment of power use has been necessary.

The situation, however, is far from good—the margin of reserve is too narrow for comfort. It will take continued vigilance to keep generating equipment on the line without adequate maintenance. It will make necessary the use of interconnections wherever possible so that whatever excess generating capacity there may be in one region can be used to supply load in areas where there is no reserve. In some cases it may make necessary the cutting off of blocks of load, particularly industrial load, for a few hours daily. Industrial establishments may be asked to change their hours of operation.

In a number of cases, utilities have reduced the voltage of the system, in fact, in a survey made by the Electrical World, 21 out of 36 utility systems may be expected to use this device, if necessary. Voltage reductions are usually from 3 to 5 per cent. And while voltage reduction does reduce power consumption, the total amount that can be saved in the case of the utilities surveyed would be only a half million kilowatts, about 4 per cent of the peak they anticipate.

Usually, a voltage drop of 1 per cent results in a 1 per cent shrinkage in demand. A decrease in voltage of over 5 per cent brings operating trouble. In some cases reduction in frequency has been tried, but this has not proved satisfactory. In some cases a reduction in frequency of from 60 cycles to 58½ cycles has been found possible, but any frequency reduction beyond that results in complaints on the part of the customers.

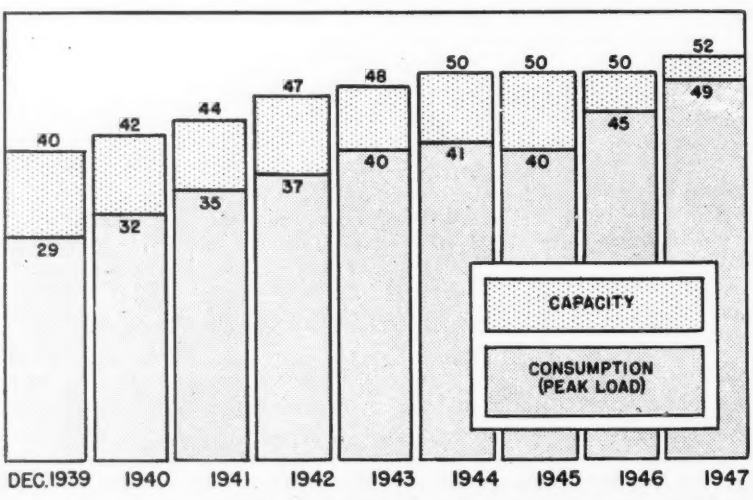


Fig. 2. The narrowing margin between power capacity and consumption. Loads are measured in millions of kilowatts

Power Situation in the United States

There is no mystery as to why this critical situation in our power supply has come about. It cannot be attributed to lack of foresight by the utilities; rather it is the result of wartime curtailment of construction. In the early years of the war, the War Production Board fought for and won a policy of building as little electric generating capacity as possible. At no time since this policy was established in 1942 has there been a possibility of building generating facilities at a greater rate than actually has been accomplished. After the war ended, orders were released to manufacturers, but the construction of electric generators and turbines is a slow process and despite the fact that the manufacturers have been producing at the highest rates in history, it has been impossible to keep up with the increasing load.

A number of factors contribute to this phenomenal increase in demand. In the first place, industrial activity is at a high level and electric production follows industrial activity. Secondly, many factories now operate one shift per day, five days per week, and hit a high peak of activity during midweek. During the war most of them operated around the clock. This change, naturally, adversely affects the load factor and helps to produce high demands. The general overall load factor, which in December, 1944, was 64.2 per cent, had dropped in December, 1946, to 58.7 per cent. In the two year period, the peak load had increased by 14 per cent while kilowatthour output had increased by only 7.5 per cent.

A third factor contributing to the high demand is the fact that the war accelerated the electrification of industry and the electrification process is definitely under way. Its influence on the growth of demand for electric power will undoubtedly be noticeable for several years ahead.

Also, to be taken into account is the fact that electricity compared to the cost of living, and particularly compared to the cost of labor, is relatively much cheaper than before the war; hence more is purchased.

Finally, a great deal of electrical energy is used in the present high level of aluminum production.

As already mentioned, the present installed generating capacity in central stations is around 52 million kilowatts. An additional 11 million kilowatts of capacity are installed in industrial plants. Thus the total generating capacity of the nation is about 63 million kilowatts.

At the present time some 13 million kilowatts of new capacity has been ordered and it is expected that in the next 5 or 6 years, from 15 to 19 million kilowatts will be installed, an unprecedented rate of installation.

Of some 11 million kilowatts of capacity reported on order, about 9 million are steam units and about 2,235,000 are hydro units. About 65,000 kw are internal combustion units. Of the hydro units, about 1,700,000 kw is destined for government projects.

There is no easy way out of this critical power situation. The position in which the electric light and power industry finds itself with respect to demand is no different from that of other industries. Like the steel industry, the makers of automobiles, the producers of petroleum, etc., the electric light and power industry is experiencing the effect of the war. A combination of unfilled pipelines, unprecedented production and growing new construction has skyrocketed power consumption far beyond the expectations of even the most farsighted. The five year construction program will go a long way towards helping the situation, but it is questionable whether we will be able to maintain the same margin of reserve in the future that we had in the past. Generating units now being installed are already loaded. The next machine is hardly placed in service before loads grow to utilize all of its much needed capacity. There never seems to be any "reserve" these days.

It is quite apparent that the shortage of reserve capacity will continue

Table I—Energy Requirements of United States

		Projected by FPC Staff					
	1946	1947	1948	1949	1950	1951	1952
Utility Systems							
Energy (billion kwh)....	224	252	267	284	295	310	326
*Demand (million kw)....	44	48	51	53	55	56	58
Industrial Generation							
Energy (billion kwh)....	51	50	50	50	50	50	50
Demand (million kw)....	10	9	9	9	9	9	9
Total Load							
Energy (billion kwh)....	275	302	317	334	345	360	376
Demand (million kw)....	54	57	60	62	64	65	67

*Total December non-coincident peak demands

Table II—Production of Generating Equipment—KW

Year	Steam	Hydro	Int. Com.	Total
1942 (actual)	2,427,000	650,000	300,000	3,377,000
1944 (actual)	1,820,000	750,000	410,000	2,980,000
1947 (estimated)	3,920,000	1,480,000	410,000	4,810,000
1951 (estimated)	5,270,000	1,550,000	550,000	7,370,000
1952 (estimated)	5,295,000	1,600,000	550,000	7,445,000

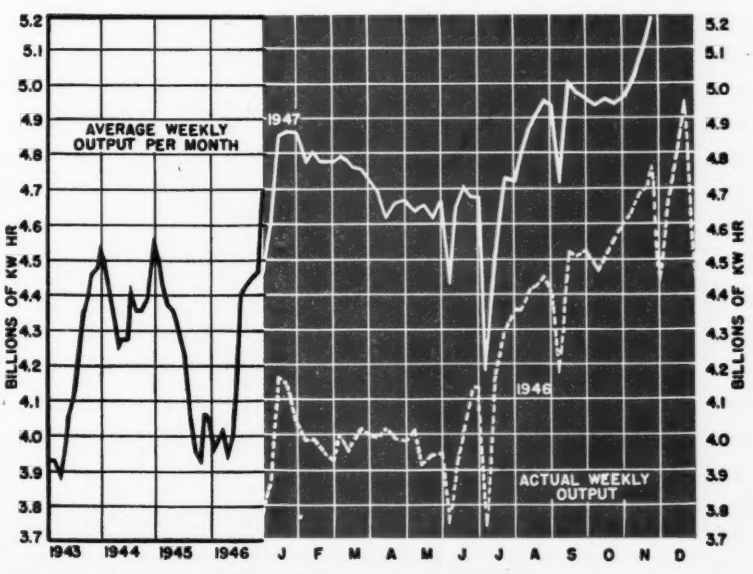


Fig. 3. The load curve during 1947

for at least a year, in spite of the new capacity being added. The energy requirements for the United States during the next five years are shown in the accompanying tabulation, Tables I and II. As will be noted by 1952 the demand will rise to 58 million kilowatts. Note that capacity in industrial power plants is expected to remain at a fixed level of 9 million kilowatts.

Table II shows the production of generating equipment, broken down into Steam, Hydro and internal combustion units.

Electrical energy, unfortunately, is not a commodity that can be stored and there may be areas where individual communities may be pinched for a short or longer period, especially in case of failure of an important unit.

Economics of Future Growth

IN OCTOBER of 1947, the production of electricity by all electric generating equipment in the United States, was at the rate of 300 billion kilowatt hours per year. This amount is almost exactly one-half of the total world generation of electrical energy in 1946, and is more than six times greater than production in any other country. The present power production is exactly double that of 1937, when the total generation reached 150 billion kilowatt hours.

This gain of 100 per cent over 1937 in the amount of electricity generated was accomplished with an increase in generating capacity, in the ten year period, of only 37 per cent. This, then, explains the narrowing margin between generating capacity and peak demands, mentioned in the first article in this section, and also, it emphasizes the need for the construction of additional generating facilities in the years to come.

While the need for future growth is very clear, the economic side of the picture presents many problems. Construction costs are extremely high, and with the present rates for electricity, it is difficult to estimate where a given expenditure for new plant facilities will bring a sufficient return on the investment, to make the expansion economically sound. When the costs of a completed project are studied these days, one must conclude that the project must have been extravagantly designed, or badly managed. And estimates for projected work are even more incredible.

As pointed out by W. F. Ryan, Assistant Engineering Manager of Stone & Webster Engineering Corporation[1], there are many factors in the present high cost level, but the price of electric power is not one of them. Power is an appreciable item in the manufacturing costs of equipment and materials, but it is one component that has not contributed to the rising commodity market. Throughout our dizzy cycles of booms and depressions, the end of each full swing of the pendulum has found electric power delivered to the consumer at lower cost than it was at the beginning, even though the cost of every major element entering into its production had increased during the same period.

Every item in the production expense for electric power has risen steadily, cycle by cycle, yet the electric industry has delivered its product at lower and lower cost. Figure 1 shows how the principal items entering into the construction of power plants have increased over the period since 1910. The curves speak for themselves — they need no explanation. Curiously enough, one of the principal items entering into the costs of electric plants, electrolytic copper, has remained relatively cheap. This is fortunate since copper is a major item in all electrical work. Structural steel shapes also have not gone up too much, but everything else has increased greatly. As will be noted, skilled labor is shown but not common labor. If common labor were shown on this chart, it would have gone off the chart in 1938, and it is now well over 600. Common labor, however, is a factor of decreasing importance in construction costs.

As pointed out by W. F. Ryan, in the same analysis previously referred to, an index of the type shown in Fig. 1 assumes the same ratio of labor hours to material quantities from year to year. It ignores the fact that a mason may lay fewer bricks per hour in 1947 than in 1913 or that an electrician may have pulled more wire in a 40 hour week in 1932 than he does now in a 53 hour week for which he gets 66 hours pay. It ignores the efficiency or rather, the inefficiency of present day labor.

Another shortcoming of the index shown in Fig. 1 is that it assumes the reproduction of obsolete plants which under no circumstances would be reproduced today. While the cost of buildings today are considerably greater, per cubic foot, than they were in 1912 or 1916, the larger generating units and the higher rates of heat transfer would reduce the building volume required for a certain capacity plant. Steam generating equipment costs more per square foot of heating surface, but the modern boiler generates more steam per square foot while the modern steam turbine requires less steam to produce a given kilowatt output.

[1] Power Plant Construction Costs and Implications. POWER PLANT ENGINEERING, August, 1947, p. 116.

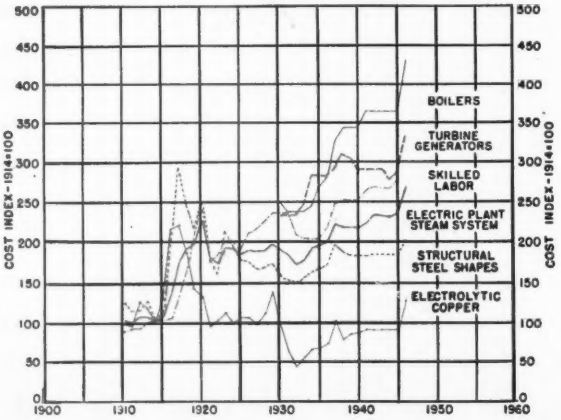


Fig. 1. Index of a number of electric plant costs and some factors affecting them

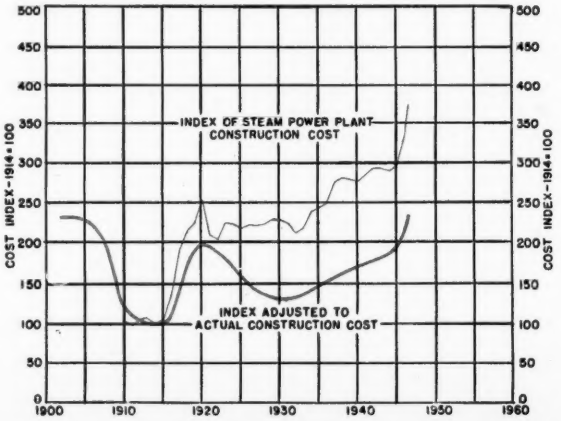


Fig. 2. Index of steam power plant construction costs and adjusted index reflecting technological advances

For these reasons, any index showing cost trends should be adjusted to account for the decrease in efficiency of labor and for the technological advances in the design of equipment. The heavy curve, in Fig. 2, shows such an adjusted index. The difference between this curve, and the unadjusted one above, is a measure of the net reduction in steam power plant cost effected by advances in the art, in spite of the adverse effects of declining efficiency of labor.

As shown, at the beginning of the century when power plants consisted of 500 hp engine driven generators and 200 hp hand fired boilers, the unit cost of power stations was high, higher than even today.

The point of all this is, that despite greatly increased labor costs and a lowering of the efficiency of labor, and also an increase in cost of almost everything entering into the construction of power plants, we have been able, steadily, to reduce the price of electricity by virtue of the technological advances in design. But how much longer can technological progress stem the tide of rising costs? It may be hoped that the costs of plant, fuel and labor which comprise the cost of power have ceilings, but it should be evident to anybody that the selling price has a floor. Perhaps, we have reached bottom so far as the price of electricity is concerned, and the day is approaching when public utilities must swallow their pride and demand an increase in rates.

This suggestion sounds reasonable, and at a time when the consumer can get more for his goods, he might not object to paying more for the electricity he uses in the production of his goods. However, when his business slumps, as it well may a few years hence, he would expect that power costs also would decrease. This, however, is where the situation becomes difficult, for the investment put into a generating plant today is frozen at that level for the rest of its useful life. True, the price of fuel may drop and the cost of labor may decrease, but fuel and labor are relatively small items in the overall cost of electric power. Construction costs also may go down, but the construction costs of a station built today, will still have to be justified as far as that station is concerned in 1960. It is this situation which makes it so difficult for the designer of a power plant today. He can never know, whether the inflated costs he builds into his station today can be recovered 20 years from now.

Yet, he must go on building stations. He cannot postpone construction to see what future conditions may bring. The power companies must keep pace with the demand for electricity no matter what the economics of the situation are.

This does not mean that the situation is hopeless. Many things, probably, can be done to reduce overall investment costs. New methods of construction, the elimination of building structures, i.e., the use of the outdoor type of plant, further simplification, greater standardization, can all add their weight toward the reduction of power station costs, and the engineer will certainly make use of all these expedients in the design of future stations.

Electric Generation and Transmission

THE LARGEST steam turbine generators so far constructed are rated at 150,000 kw. Two machines of this size are being installed, one at Southwark Station in Philadelphia and the other at Fisk St. Station in Chicago. The one at Southwark is a cross compound unit, the high pressure element operating at 3600 rpm, while the low pressure element is an 1800 rpm unit. The 150,000 kw machine at Fisk St. Station is a single 1800 rpm unit.

Of the turbine generator units now on order, approximately 85 per cent of the total capacity is designed to operate at 3600 rpm. The largest of these is rated at 100,000 kw. It is quite likely that future units with ratings over 100,000 kw will operate at 1800 rpm.

For the benefit of all concerned and with the cooperation of the central stations companies, the electrical manufacturers have standardized on six preferred ratings for large 3600 rpm condensing units as follows: 11,500; 15,000; 20,000; 30,000; 40,000; and 60,000 kw. The two larger sizes are available for steam conditions of either 850 lb at 900 F or 1250 lb at 950 F. At ratings above 60,000 kw it usually works out that the designs are more or less special, although every effort is made to standardize even in these large sizes.

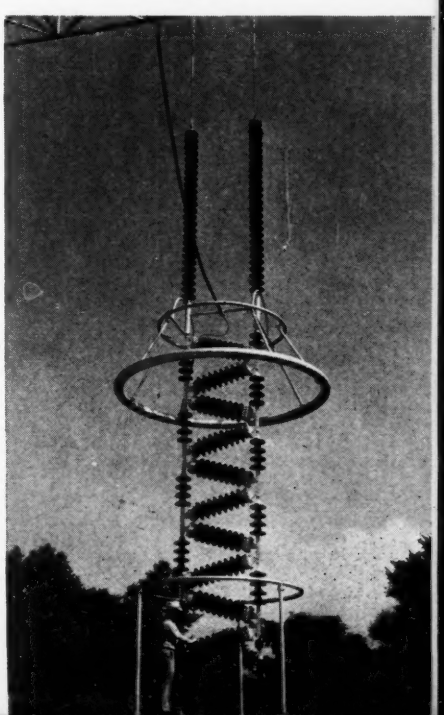
Approximately 93 per cent of the new generating capacity is hydrogen cooled. Recent improvements in the design of the hydrogen sealing and purifying arrangements indicate that hydrogen cooling will be extended to still smaller units. Availability of hydrogen-cooled generators has been practically perfect. Most hydrogen-cooled generator units have been designed for 15 psig operation to obtain maximum rating but only a few are operated at this pressure.

Double frequency vibrations which had been experienced in the operation of the early 3600 rpm turbine generators have been eliminated by machining relatively narrow cross-wire slots in the pole body at intervals along the body length. This equalizes the rotor-body rigidity on the two major axis and can be realized without removing an appreciable amount of rotor pole material. Double frequency forces in the 2-pole generator stator cannot be eliminated. However, the magnitude of these forces transmitted to the stator frame and generator foundations are effectively minimized by isolating the stator core on flexible supports; these supports absorbing practically all of the vibration energy.

Hydroelectric generators, as in the past, are characterized by large dimensions. For this reason, hydroelectric generators of large capacity must be built in sections and assembled at the point of installation. This has led to problems of fabrication which were difficult of solution, but most of which have been met. While the building of the components at the user's plant results in units of greater mechanical stability with less need for later maintenance, the initial cost is higher. For this reason as much fabrication as possible is done at the manufacturer's plant.

Much interest is being taken in the newly developed silicone compounds. Motors insulated with silicone insulation have been operated at temperatures so high that the metal parts failed before the insulation. Silicone insulating varnishes, so far have been

A view of the half million volt lightning arrestor at the Brilliant, Ohio, test transmission line



applied to windings only up to 4000 v. If they can be used on higher voltages, their use may effect material improvements in generator design.

A notable recent project is the conversion of the Southern California Edison Company's system from 50 to 60 cycles. This is a 2 year project involving an expenditure of 31 million dollars. The project not only necessitates conversion of large rotating equipment, but also of some half million watthour meters, and thousands of motors on customer appliances.

Two of four 60,000 kw turbo-generators are now being installed at the Redondo Beach Steam Station of the Southern California Edison Co. An electrical feature, entirely new to large generators, will be the application of General Electric's amplidyne field control to one of these units and Westinghouse's Rototrol to the other. These systems will provide high-speed response and better voltage regulation. Southern California Edison has pioneered in this type of field control with two successful applications of the Amplidyne, one to a 50,000 kw synchronous condenser, and the other to a 60,000 kw frequency changer.

One of the outstanding events in the field of high voltage electric transmission, was the energizing, on October 1, of the 500,000 volt test transmission line at Brilliant, Ohio[1]. This line was fully described in the November issue so only brief mention need be made of it here. It was built under the sponsorship of the American Gas and Electric Service Corp. in cooperation with a number of electrical equipment manufacturers who contributed the actual equipment. The project comprises three separate lines, two 1½ miles in length and the third only one span in length. The two 1½ mile lines have an average span of about 1050 ft and comprise six towers each, two of which are dead-end structures. The lines run parallel and are 288 ft apart. Conductors are 85 ft above ground at the tower, and 40 ft at mid span.

The designers of these lines believe that extra high voltage transmission systems, systems above 230 kv, must be permanently, and solidly, grounded at all transformation points. This will permit the use of reduced voltage lightning arrestors. Such solid grounding, when used with circuit breakers that will open the circuit with no more than a single re-strike will limit the magnitude of the voltage in switching transients to which the lines will be subjected.

[1] Half Million Volt Test Transmission Line Energized, POWER PLANT ENGINEERING, November, 1947, p. 72.

New Generating Installations

THE ELECTRIC Light and Power Companies, during the past year inaugurated the largest construction job ever undertaken by a single industry for a 5 year period. As reported in another article in this section, a recent Edison Electric Institute survey shows that the total capacity to be added during the five year period from 1947 to 1951 inclusive amounts to 18,000,000 kw of which 15,000,000 kw will be installed by privately owned power companies. This will be an increase in the five year period of 37½ per cent; about the total installation constructed in the previous 65 years.

The amount of money to be spent in the execution of this program is truly astounding. A total of **five billion dollars** will be spent. Of this, $1,750,000,000 will go into the construction of generating stations. Transmission lines will account for $850,000,000. Distribution lines will require $2,150,000,000 and service buildings, $250,000,000. About 40 per cent of the total 5 billion, that is 2 billion dollars, will be spent for local labor on construction projects. The remaining 60 per cent will go for the purchase of equipment and supplies.

The accompanying tabulation, Table II, shows a preliminary listing of new generating capacity to be added under the 5 year program by the various power companies. This is a preliminary listing, not complete. The total orders included in this list, it will be noted, amount to about 12,500,000 kw of capacity. Deliveries of power generating equipment are now scheduled as follows: 1947—3,257,000 kw; 1948—5,215,000 kw; 1949—4,915,000 kw; 1950—3,383,000 kw; 1951—so far ordered, 1,000,000 kw. Steam power constitutes about 15½ million kilowatts, hydro power about 2½ million kilowatts.

In considering the expansion of the power facilities of the nation, it is of interest to note where the expansion and load changes occur. The Edison Electric Institute, made a survey during the year, the results of which are shown in Table I. Here, the capacity changes and peak load changes are shown for the eight regional groupings of supply areas, for the various years to 1950. The map shown in Fig. 1 will serve to identify the regional areas.

Over two million new customers came on the power lines in 1947, making the largest increase in any one year of the industry's history. Since VJ-Day more than 4½ million new customers have been added. Supply of construction materials has improved and the backlog of customers awaiting service has been sharply reduced. The total number of customers at the end of 1947 was approximately 38,400,000.

About 500,000 additional farms were added to power lines during the year, bringing the total to over 3,800,000 farms served with electricity.

Electricity Production

Production of electricity during the year was divided approximately as follows:

By business-managed electric companies, 204 billion kilowatthours.

By governmentally-owned systems, 50 billion kilowatthours.

By industrial plants, street railways and miscellaneous producers, 51 billion kilowatthours, for their own use.

Table I. Expected 1947-1951 Capability Additions and Load Growth Expressed in Percentages

	CAPACITY CHANGES					PEAK LOAD CHANGES				
	1947 1946	1948 1947	1949 1948	1950 1949	1951 1950	1947 1946	1948 1947	1949 1948	1950 1949	1951 1950
U. S.	6.3	10.5	9.1	6.8	3.4	10.5	7.2	6.7	5.6	3.9
Region I	6.6	11.9	6.2	5.7	2.6	9.0	4.7	3.2	2.5	2.9
Region II	5.3	8.2	13.0	5.5	..	9.6	7.7	5.7	4.6	..
Region III	4.4	10.7	8.0	12.1	5.7	8.8	8.6	7.5	6.4	..
Region IV	9.1	6.3	10.8	3.2	5.4	10.9	7.0	6.7	6.0	6.0
Region V	8.8	9.1	15.4	13.2	5.4	23.0	11.6	9.3	7.8	6.6
Region VI	17.5	23.4	0	18.8	12.7	16.5	9.9	..	..	..
Region VII	..	10.1	13.6	..	..	..	7.0	..	..	..
Region VIII	6.0	17.0	5.0	9.1	..	10.8	8.7	10.0	9.1	..

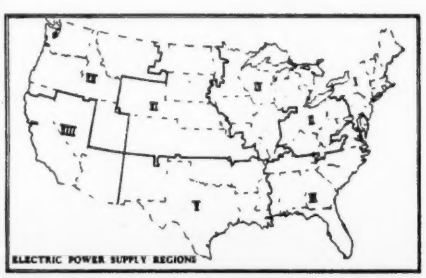


Fig. 1. Electric power supply regions in the United States

Total sales of electricity by all utility enterprises, both company and governmental, approximated 216 billion kilowatthours, a 12 months' increase of 13 per cent above the year 1946. The largest growth was in the residential and commercial classifications, both up 15 per cent. Industrial use remained at a fairly constant level throughout the year.

Interconnection Can Help Relieve Power Shortages in Local Areas

While power generating capacity is being added as rapidly as possible, attempts are also being made wherever possible to meet the increased demands by interconnection. Interconnection, however, does not always solve the problem. Some large system interconnections seem too cumbersome for successful operation. During the period of expansion and interconnection of power systems, some companies have experienced declines in the ability of the early moderate voltage interconnecting lines to transmit sufficient intersystem synchronizing power. This has been due to load growth, heavy transmission line loading and increased generating capacities. As a result, higher transmission voltages were subsequently utilized to transmit intersystem synchronizing power.

Various steps have been taken to combat the decline in synchronizing power ability. High speed relaying, high-speed circuit breakers, frequency control, tie, line control, etc. All of these developments have been aimed toward solution of the problems associated with the operation of interconnected systems and while a great deal of success has been attained, it has not always been possible to maintain adequate service to all parts of an interconnected system under sustained fault conditions.

So, while interconnection can be of help in relieving power shortages in local areas, it cannot be counted on to relieve the national situation on a whole. Only the rapid execution of the 5 year expansion program can effectively solve the problem.

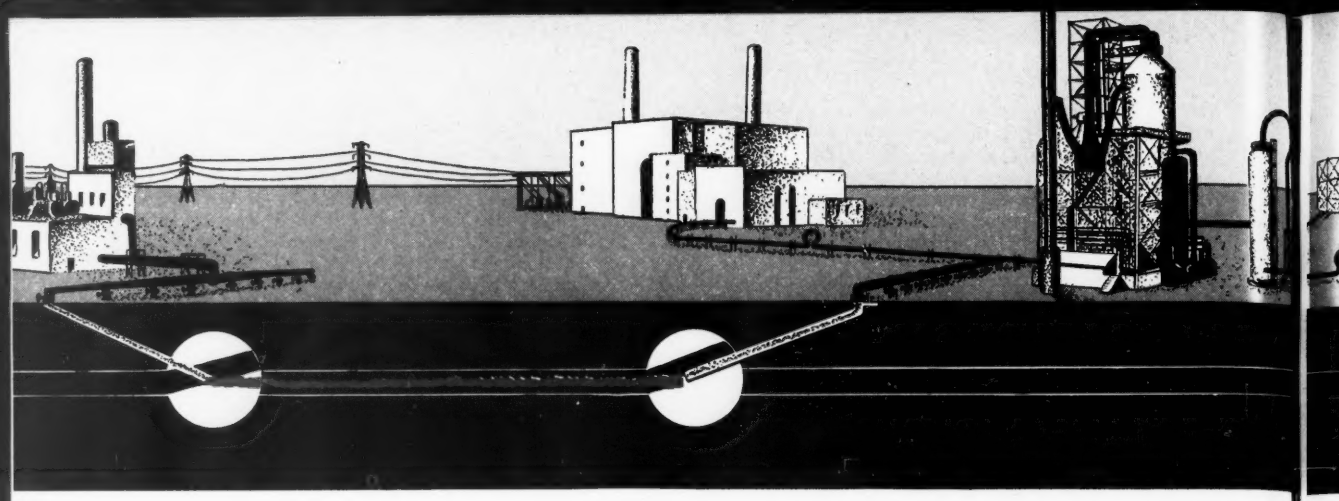
TABLE II—NEW GENERATING CAPACITY INSTALLATIONS

To Be Added in the Business-Managed Electric Company's Five Billion Dollar Expansion Program

Total orders listed here amount to about 12,500,000 kw of capacity. Additional capacity totaling more than 1,000,000 kw is contemplated for installation in 1951

Listed by Companies, Expected Year of Installation and Manufacturer's Nameplate Rating of Generator Capacity in kilowatts

Company	July-Dec. 1947	1948	1949	1950
Alabama Power Co.	20,000	.....	120,000	.....
Almno System	.....	68,000	150,000	80,000
Appalachian Electric Power Co.	.....	.....	135,000	.....
Arkansas-Missouri Power Co.	.....	.....	30,000	.....
Boston Edison Co.	50,000	.....	85,000	.....
California-Oregon Power Co.	.....	25,000	.....	.....
Cambridge Electric Light Co.	.....	18,000	.....	.....
Carolina Power & Light Co.	.....	.....	.....	88,000
Central Ariz. Light & Power Co.	.....	30,000	.....	.....
Central Illinois Electric & Gas Co.	.....	.....	20,000	.....
Central Illinois Light Co.	.....	.....	35,000	.....
Central Illinois Public Service Co.	50,000	.....	.....	.....
Central Kansas Power Co.	.....	.....	6,500	.....
Central Louisiana Electric Co.	.....	15,000	.....	.....
Central Maine Power Co.	20,000	16,800	.....	.....
Central Power & Light Co.	20,000	.....	50,000	.....
Cincinnati Gas & Electric Co.	.....	35,000	80,000	.....
Cleveland Electric Illg. Co.	.....	85,000	85,000	71,000
Columbus & Sou. Ohio Elec. Co.	.....	60,000	.....	.....
Commonwealth Edison Co. & Subs.	107,000	.....	257,000	.....
Connecticut Light & Power Co.	.....	36,000	.....	63,000
Connecticut Power Co.	.....	5,000	.....	.....
Consolidated Edison Co. of N. Y.	50,000	170,000	50,000	120,000
Consolidated Gas, Electric Light and Power Co.	.....	60,000	.....	61,000
Consumers Power Co.	.....	170,000	180,000	60,000
Dallas Power & Light Co.	.....	.....	63,000	63,000
Dayton Power & Light Co.	.....	50,000	50,000	.....
Detroit Edison Co.	.....	.....	100,000	200,000
Duke Power Co.	.....	130,000	.....	130,000
Duquesne Light Co.	.....	.....	81,000	.....
Eastern Shore Public Service Co.	15,000	.....	15,000	.....
El Paso Electric Co.	.....	.....	20,000	.....
Empire District Electric Co.	.....	.....	.....	30,000
Fitchburg Gas & Elec. Light Co.	.....	.....	.....	10,000
Florida Power Corp.	.....	30,000	.....	30,000
Florida Power & Light Co.	.....	58,750	37,500	40,000
Georgia Power Co.	.....	122,500	22,500	80,000
Gulf Power Co.	.....	.....	22,500	.....
Gulf States Utilities Co.	38,000	.....	42,000	75,000
Hartford Electric Light Co.	.....	15,000	45,000	.....
Holyoke Water Power Co.	.....	15,000	.....	.....
Houston Lighting & Power Co.	37,500	10,000	120,000	60,000
Idaho Power Co.	16,500	40,700	30,000	.....
Illinois Power Co.	.....	.....	80,000	.....
Indiana-Michigan Electric Co.	.....	.....	135,000	.....
Indianapolis Power & Light Co.	.....	.....	40,000	40,000
Interstate Power Co.	.....	15,000	.....	.....
Iowa Electric Light & Power Co.	5,000	.....	.....	.....
Iowa-Illinois Gas & Electric Co.	.....	5,000	40,000	.....
Iowa Power & Light Co.	.....	.....	.....	40,000
Iowa Public Service Co.	3,408	4,544	15,000	.....
Jersey Central Power & Light Co.	.....	.....	36,000	.....
Kansas City Power & Light Co.	35,000	.....	.....	.....
Kansas Gas & Electric Co.	.....	29,000	.....	31,000
Kansas Power & Light Co.	.....	30,000	.....	40,000
Kentucky Utilities Co.	30,000	30,000	33,000	33,000
Lake Superior District Power Co.	.....	15,000	.....	.....
Long Island Lighting Co.	.....	40,000	40,000	.....
Louisville Gas & Electric Co.	60,000	.....	60,000	.....
Luzerne County Gas & Elec. Co.	23,000	.....	.....	.....
Madison Gas & Electric Co.	.....	20,000	.....	.....
Metropolitan Edison Co.	48,000	.....	.....	66,000
Minnesota Power & Light Co.	.....	.....	45,000	.....
Mississippi Power Co.	.....	.....	22,500	.....
Missouri Utilities Co.	.....	.....	8,000	.....
Monongahela Power Co.	.....	.....	50,000	.....
Montana-Dakota Utilities Co.	6,000	9,000	.....	.....
Montana Power Co.	.....	.....	60,000	.....
Montaup Electric Co.	35,000	.....	.....	.....
Mount Carmel Public Util. Co.	4,000	.....	.....	.....
Nantahala Power & Light Co.	2,000	.....	.....	.....
New Bedford Gas & Edison Lt. Co.	20,000	.....	.....	.....
New England Electric System	45,000	.....	75,000	.....
New Jersey Power & Light Co.	.....	.....	66,000	.....
New York State Elec. & Gas Co.	.....	30,000	.....	70,000
Niagara-Hudson Power Corp.	.....	180,000	67,500	195,000
Northern Indiana Public Serv. Co.	.....	.....	.....	66,000
Northern States Power Co.	42,500	37,500	65,000	30,000
Northwestern Public Service Co.	2,272	7,500	.....	.....
Ohio Edison Co.	48,000	52,000	60,000	60,000
Ohio Power Co.	.....	100,000	.....	135,000
Ohio Public Service Co.	65,000	65,000	.....	.....
Oklahoma Gas & Electric Co.	.....	25,000	50,000	.....
Otter Tail Power Co.	9,900	19,500	.....	.....
Pacific Gas & Electric Co.	.....	356,000	68,000	220,000
Pennsylvania Electric Co.	.....	30,000	30,000	40,000
Pennsylvania Power Co.	35,000	.....	.....	.....
Pennsylvania Power & Light Co.	.....	150,000	.....	.....
Peoples Gas & Electric Co.	.....	.....	7,500	.....
Philadelphia Electric Co.	.....	235,000	66,000	165,000
Potomac Edison Co.	35,000	.....	35,000	.....
Potomac Electric Power Co.	50,000	.....	80,000	80,000
Public Electric Light Co.	5,000	.....	.....	.....
Public Service Co. of Colorado	.....	40,000	.....	40,000
Public Service Co. of Indiana	.....	47,000	.....	50,000
Public Service Co. of New Hamp.	30,000	15,000	33,000	7,000
Public Service Co. of New Mexico	6,000	11,500	.....	.....
Public Service Co. of Oklahoma	30,000	15,000	.....	30,000
Public Service Electric & Gas Co. of New Jersey	100,000	200,000	100,000	.....
Rochester Gas & Electric Co.	.....	80,000	.....	.....
Rockland Light & Power Co.	.....	.....	20,000	.....
San Diego Gas & Electric Co.	50,000	.....	.....	50,000
Savannah Electric & Power Co.	.....	.....	20,000	.....
Scranton Electric Co.	.....	32,000	.....	.....
Sioux City Gas & Electric Co.	.....	10,000	.....	.....
South Carolina Power Co.	22,500	.....	.....	22,500
Southern California Edison Co.	22,000	155,000	120,000	.....
Southern Colorado Power Co.	.....	15,000	.....	.....
Southern Indiana Gas & Elec. Co.	.....	.....	22,000	.....
Southern Wyoming Utilities Co.	7,500	.....	.....	.....
Southwestern Gas & Electric Co.	25,000	.....	25,000	30,000
Southwestern Public Service Co.	.....	53,000	43,000	.....
Staten Island Edison Co.	25,000	.....	.....	.....
Tampa Electric Co.	.....	30,000	.....	60,000
Texas Electric Service Co.	.....	70,000	.....	.....
Toledo Edison Co.	.....	.....	100,000	.....
Union Electric Co. of Mo. & Subs.	.....	80,000	.....	80,000
United Illuminating Co.	.....	30,000	.....	30,000
Utah Power & Light Co.	.....	.....	.....	44,000
Virginia Electric & Power Co.	.....	130,000	.....	140,000
Western Massachusetts Elec. Co.	.....	.....	45,000	.....
West Penn Power Co.	.....	80,000	.....	80,000
West Texas Utilities Co.	.....	7,500	.....	.....
Wisconsin Electric Power Co.	.....	80,000	80,000	.....
Wisconsin Michigan Power Co.	.....	.....	17,800	.....
Wisconsin Public Service Co.	30,000	.....	50,000	.....
Yearly TOTAL	1,381,080	3,931,794	3,942,300	3,235,500
TOTAL, July, 1947-1950				12,490,674



Energy Revolution on the Verge?

COAL, THE KING of our energy sources, expects a brighter future, as a result of some of this year's developments, than seemed possible only a short time ago. We are on the verge of a revolution in energy transformation, with coal as the key material, almost as important as the discovery of nuclear fission itself. For we need not wait 8 or 10 years, as David E. Lilienthal, head of the AEC, says we must, for practical commercial atomic energy power plants. Yet we need not have jitters about our increasing need for more Diesel and gasoline engines in face of diminishing oil reserves, figured to last 15 years, or our natural gas reserves, figured to last 30 years.

Instead, here and now in 1948, we have the beginnings of an energy revolution heralded by a number of the important developments of the past year, as reported in POWER PLANT ENGINEERING.

Coal's illnesses were put under the microscope and dissected without mercy in a famous article in *Fortune*, March and April, 1947.

Nevertheless, present developments point to the possibility that we can synthesize all the oil we need from coal or natural gas. We might quickly double our oil supplies by this technique. It depends on (a) fluid bed catalytic reactions — Lurgi, Bergius, Fischer-Tropsch and modifications thereof—and (b) production of cheap chemical oxygen. Utilizing these, there is no impending oil shortage; there is impending competition between gas from coal and natural gas, also between coal moved as gas and coal moved as such, as pointed out by P. C. Keith. Coal transported as oil is yet too expensive and may not be competitive for some time. But gasoline from natural gas or coal may soon compete with gasoline from crude petroleum.

Coal treated as a raw material may soon drive out coal-by-the-lump with all its attendant problems and its outmoded "material-handling" philosophy. If it must be mined, it will be by improved machines and methods, and, at the mine mouth, most of it might go into synthesis gas plants. Instead of consuming 600,000,000 tons of coal a year, we may need 1,200,000,000 tons a year. If this has to be dug out of the ground it will be costly, hence the interest now developing in burning it underground.

Processes for making liquid fuels and various gases and chemicals from natural gas and coal depend largely on the ability to produce cheap oxygen. A process based on the Linde-Fraenckl method developed in Germany has been worked out and P. C. Keith expects it to yield oxygen at $2 per ton. This makes possible the Hydrocol plant in Texas and a Stanolind plant in Kansas, for processing natural gas into gasoline. (The latter was described in detail, in August, 1947 issue by Roberts and Phinney.)

Cheap oxygen will also make possible some processes now under investigation for recovering the low-grade iron ores of the Mesabi range. In steel-making, compressed air and oxygen are already being tried in blast furnace and open hearth practice. By these means, it is estimated

Table giving comparison of coal conversion processes (*Westinghouse Engineer*, September, 1947)

	Reaction Pressure and Temp.	Raw Materials	Products per Ton of Coal*	Rank of Coal Suitable				
				Anthracite	Low-Volatile Bituminous	High-Volatile Bituminous	Sub-Bituminous	Lignite
Blue Water gas	Atmos. 2800° F	Coal Steam Air	55000 cu ft 290-Btu gas per ton of coke	Yes	Yes	Yes	No	No
High-Temp. Carbonization	Atmos. 1500 to 2000 (1700° F average)	Coal Heat	1400 lb coke 11 000 cu ft gas 13 gal tar and light oil 28 lb chemicals	No	Yes	Yes	No	No
Low-Temp. Carbonization	Atmos. 1000° F	Coal Heat	1440 lb coke 15 gal tar 3700 cu ft gas	No	Yes	Yes	No	No
Hydrogenation (Bergius)	800-900° F 3000 to 10 000 psi	Coal Hydrogen Catalyst	80 gal gasoline 20 gal liquified gases 425 cu ft 535-Btu gas	No	No	Yes	Yes	Yes
Gas Synthesis (Fischer-Tropsch)	(1) 2800° F 30-150 psi (2) 300-400° F 0-150 psi	Coal Oxygen Steam Catalyst	8000 cu ft 350-Btu gas 20 gas gasoline, propane, etc. 15 gal Diesel oil 125 lb wax	Yes	Yes	Yes	Yes	Yes

*Results for hydrogenation and gas synthesis are based on German experience which should be considerably bettered in American plants. Water-gas products are based on one ton of coke and hence require coking coals.

Since this table was compiled fluid devolt-atilization process has been announced (October, 1947 issue). Using raw coal: Reaction temperatures 752 to 932 F. Yield per ton of coal shipped; char 77.7 to 56.8 per cent; gas 532 to 2050 cu ft; tar 168 to 354 lb. Heating value gas 639 to 630 Btu per cu ft. Using oxidized coal, reaction temperatures 932 to 1472 F. Yield per ton coal shipped; char, 61.0 to 52.5 per cent; gas, 2045 to 12,700 cu ft; tar, 236 to 83 lb. Heating value of gas 484 to 578 Btu per cu ft.

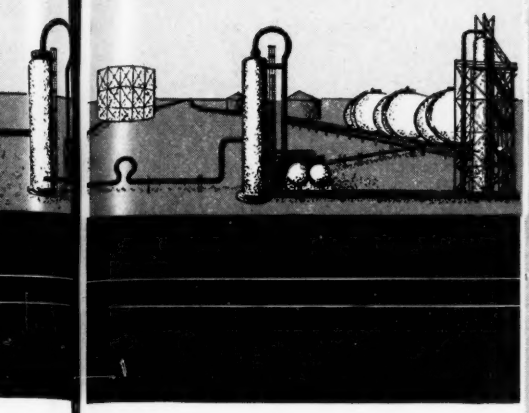


Fig. 1. Power plants of the future may be centers of processing activity. If coal can be successfully burned underground, yielding gas for synthesis into liquid fuels and by-products, operation of gas turbines and steam turbines, transmission of power electrically and of gas and synthetic oil by pipe lines, the "materials-handling" philosophy of coal will disappear. If coal must be mined, it may be converted into synthesis gas and by-products at the mine mouth. Natural gas also may soon be a source of synthetic gasoline, Diesel oil, and so on. (Adapted from *Fortune*, April 1947)

that capacity of present open hearths could be increased—the optimists say 25 per cent. Possibilities of steel and even boiler furnaces especially designed for oxygen are being discussed.

Gasification of coal by various methods will soon be under way. Work is going forward rapidly on the pilot plant sponsored by Pittsburgh Consolidation Coal Co. at Library, Penn. in co-operation with oil and other companies, as outlined by George H. Love (August, 1947 issue).

Work in synthesizing gases and liquid fuels from oil shale lignite, peat and sub-bituminous coals by various methods, including hydrogenation, has been carried on in experimental plants for year by U. S. Bureau of Mines.

Underground gasification of coal has been investigated by the Alabama Power Co. and the U. S. Bureau of Mines, as reported in September, 1947 issue. This process, as carried out in the Alabama experiment, yielded gases of between 50 and 100 Btu per cu ft, although, by introduction of oxygen, 150 Btu gas resulted and by use of steam, a small amount of 291-Btu gas was produced. Similar results of underground gasification are reported in Russia.

One method developed years ago for oil well drilling consists of boring holes horizontally underground. If this could be used in coal instead of the shaft, tunnel and drift methods discussed above, its advocates believe the cost of underground gasification could be greatly reduced.

Another technique, fluid devolatilization, has been developed for extracting gases of high heating value from coal and transforming a high percentage of the coal into a char. This char, as explained by Singh in the October, 1947 issue, pulverizes well; but without pulverizing might be well adapted to the new cyclone burner.

With such developments as the above, our solid fuels will supplement declining oil and gas reserves and meet all our fuel needs for from 1000 to 2000 years.

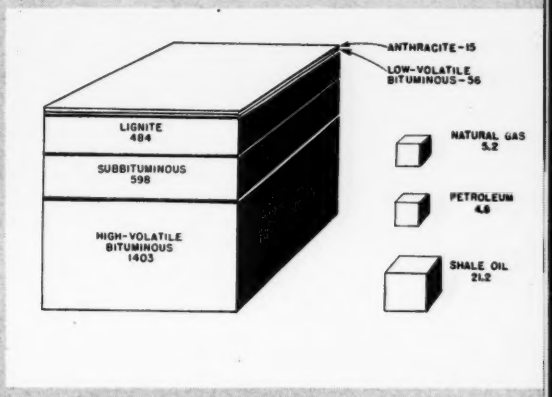


Fig. 2. Reserves of mineral fuels in U. S. as of January 1, 1946, in equivalent billions of tons of 13,000-Btu coal. Solid fuel could supply all hydrocarbon needs for 1500 years. (Ralph A. Sherman: Energy Sources for Tomorrow, 1947, Midwest Power Conference)

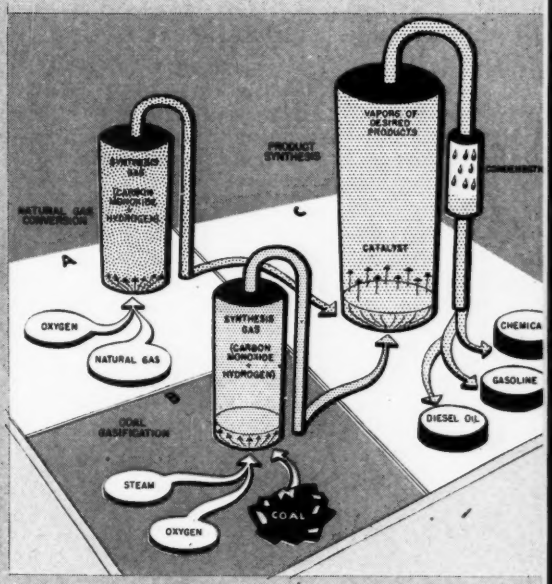


Fig. 3. How coal or natural gas is converted into gasoline. Block A shows how natural gas and a limited supply of oxygen are burned in a reactor to form CO and H. Block B shows how coal, steam and oxygen react to form CO and H. The mixture then flows to a chamber, Block C, containing a catalyst and various reactions occur to produce Diesel oil, gasoline, and various chemicals and gases. (Adapted from *The Lamp*, Standard Oil Co. of New Jersey)

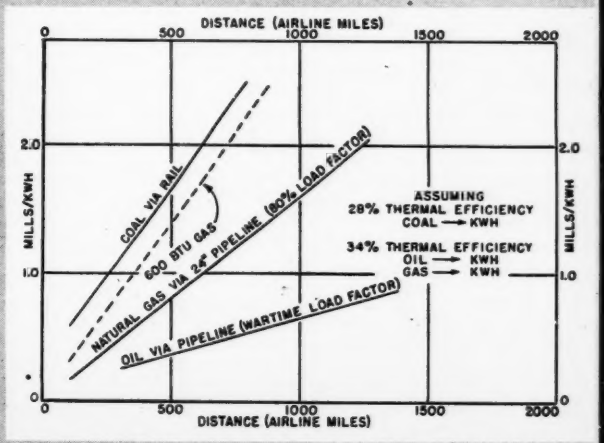
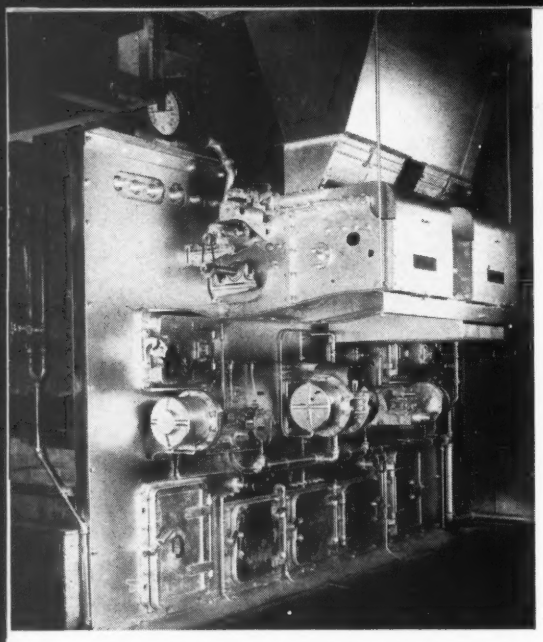


Fig. 4. Cost of energy transmission in form of different fuels at 28 per cent overall efficiency (assumed) for coal burning power plants and 34 per cent efficiency for Diesel and gas-engine plants. (P. C. Kieth, paper at Princeton University, via *Combustion*, 1946)



Developments of 1947 in Power Station Design

Steam turbine generator construction comes back with a bang! . . . Standardized turbine generators . . . Large units . . . Top steam temperature now 1050 F; several units under construction . . . Several reheat stations to come . . . Reheating in the turbine . . . Double-circulation boiler . . . Designs for wide fuel flexibility a post-war feature . . . Pulverizers and spreader stokers . . . Smoke abatement, fly-ash elimination, overfire jets, venturi gas scrubber . . . Instruments, controls . . . Dual-fuel Diesel

Fig. 1. Spreader stoker with link-grate mechanism, firing a 39,000-lb-an-hr boiler (45,000 lb max) at American Home Foods, Inc., Rochester, N. Y.

CONSTRUCTION of steam turbine generators is progressing at a terrific pace, yet even this is not enough to meet the demand.

In steam generation, the top steam temperature of 1050 F, toward which designers have been reaching, will be attained this year by several utility plant units. Also, in some of these, reheat will be used.

There is much interest in the spreader stoker, especially for industrial boilers. Smoke abatement and prevention of fly-ash emission are of great concern to operators.

Turbine Generators Are in the News Again

Between war's end and the fall of 1947, one manufacturer undertook the construction of about 80 large generating units totaling 3,500,000 kw or nearly 7 per cent of the total installed central-station steam capacity in the United States. A large proportion of these are standardized units. Forty-six standard units, aggregating about 2,000,000 kw, have been built or are under construction by this one manufacturer (as of October 1).

Among these, the distribution by rating is: eighteen 60,000-kw; seven 40,000-kw; eighteen 30,000-kw; the remaining three are the smaller sizes. Six are designed for 1250-psig, 950-F steam and thirty-seven for 850 psig, 900 F.

Top Steam Temperature Now 1050 F

Another important and difficult increment has been taken in steam temperature. The top now rests at 1050 F. The first units at this new peak will be the 100,000-kw machines for the Sewaren Station, Fig. 7, on the line this year. Another unit for this top temperature is a three-casing, 150,000-kw, cross-compound machine for Ridgeland Station. The Mistersky Station extension for the City of Detroit has also been designed for 1050 F.

The new 25,000-kw unit at Missouri Avenue Station, Atlantic City, N. J., is now in operation at its designed temperature of 1000 F.

For machines operating with temperatures above 950 F, materials are being worked to their allowed physical limit. Throttle valves, steam chests, nozzle chambers and other parts subjected to the high temperatures are made of forgings or relatively simple castings.

Large Units Under Construction

Among machines notable for size is the first 150,000-kw unit, Fig. 2, in the Southwark Station. It will be followed by a duplicate for service early in 1948. Several 80,000-kw (100,000-kw maximum) 3600-rpm condensing units, such as one for the Buffalo Niagara Electric Co., mark the extension of the 3600-rpm, single-shaft turbine into the larger sizes for 1250 psig, 950 F or 850 psi, 900 F. Of interest is the 30,000-kw noncondensing automatic double-bleeder industrial power plant turbine to be installed by the Dow Chemical Co. Another 65,000-kw turbine with steam conditions of 1450 psi, 1000 F, employs reheating to 1000 F.

Larger stationary, low-pressure blades are now made hollow by one manufacturer. Considering the size of these blades and that they are made of relatively expensive stainless steel, it is a worth-while economy of material and weight, to fabricate the blade instead of casting it solid.

Is Reheat Coming Back?

The reheat cycle gave way for some years to steadily increasing steam temperatures, to achieve desired economy and dry steam in final turbine stages. Now, however, designers have reached, at least for a while, another upper temperature limit and do not yet know whether they can go further. This, with the increasing price of fuel, makes designers look again at reheat, which is not new, as a masterly review of earlier reheat installations in *Combustion*, September, 1947 points out.

New installations being designed for reheat are a 65,000-kw, 1600-psi, 1000-F extension to Edgar Station, a 2300-psi, 1050-F unit for American Gas & Electric Co. and the latest extension to Port Washington. All are one-boiler-turbine or unit designs, so there is no problem of distributing reheated steam. This simplifies piping and valves.

Sub-Saturation Reheating in the Turbine

A proposal has been made for reheating steam directly in the low-pressure stages of the turbine by bleed steam introduced into hollow stationary blades or nozzle partitions. This was advanced by W. E. Caldwell, Consolidated Edison Co. of N. Y. at the ASME Annual Meeting, 1947. This method would dry the steam in the last stages of the turbine, without the necessity of withdrawing it to a reheat boiler. Thus the turbine initial pressure could be higher, but initial temperature could be lower and still insure dry steam in last turbine stages, with ease of control, lower production cost and less capital investment than other methods, says Mr. Caldwell.

Steam Generating Units

A most important factor in design today is the influence of a group of engineers who have advocated improved design of boiler equipment to

save fuel dollars. Notable among these is Julian E. Tobey of Fairmont Coal Bureau, who has constantly led in advocating design for the widest fuel-burning flexibility. The accompanying table is from his report on 600 boiler installations installed within the last two years. In these, furnaces have sufficient volume and water-cooling to burn the full range of coals available to them economically within the life of the equipment. Heat release rates range between 15,000 and 25,000 Btu per cu ft per hr. Units range from 10,000 to 1,000,000 lb per hr steam capacity.

The units are designed with pulverizers of sufficient capacity, stokers with sufficient grate areas to avoid excessive fuel bed temperatures. By designing for coals of ash softening temperature of 2000 F minimum, grindability of 50 Hardgrove minimum, maximum sulphur 3.5 per cent, maximum moisture 10 per cent, tolerance and factors of safety are introduced that have assured high capacity, low maintenance and economy with a wide range of coals.

Pulverizing Developments

There has been development in details of pulverizing mills during the year. Interest in the effect of fineness on capacity and size of equipment, especially as applied to the open-cycle gas turbine, led Martin Frisch to report on characteristics of jet pulverizers before the ASME. A new steam atomizing type of pulverizing mill was placed on the market, as described in detail in July, 1947, issue.

Figure 4 shows a recently-announced ball mill designed to secure fine pulverizing at low maintenance cost without frequent shut down for repair or service. It incorporates a spreader feeder, designed to distribute the coal uniformly through the length of the mill, minimize troubles with wet coal, and give high capacity. It has a 3-point suspension on roller bearings; standard speed electric motor drives through automatic clutch for smooth starting; enclosed reduction gear mechanism; automatic lubricating system; noise and vibration deadening not only of shell but of driving gear mechanism; design for low-headroom.

A recent boiler design of interest is the dual-circulation unit of Fig. 3, designed to handle 100 per cent make-up without excessive blowdown and with reduced scaling in high-temperature heat absorbing zones. The unit has separate circulating systems for primary or radiant section and secondary or convection section. Feedwater is delivered to the drum of the primary section and circulation to the water walls is taken entirely from this drum. The primary section is blown down continuously to supply feed to the secondary section.

Advantages: (1) reduced concentration and lower maintenance; (2) lower percentage of blowdown, lower heat loss with same maximum concentration is radiant section.

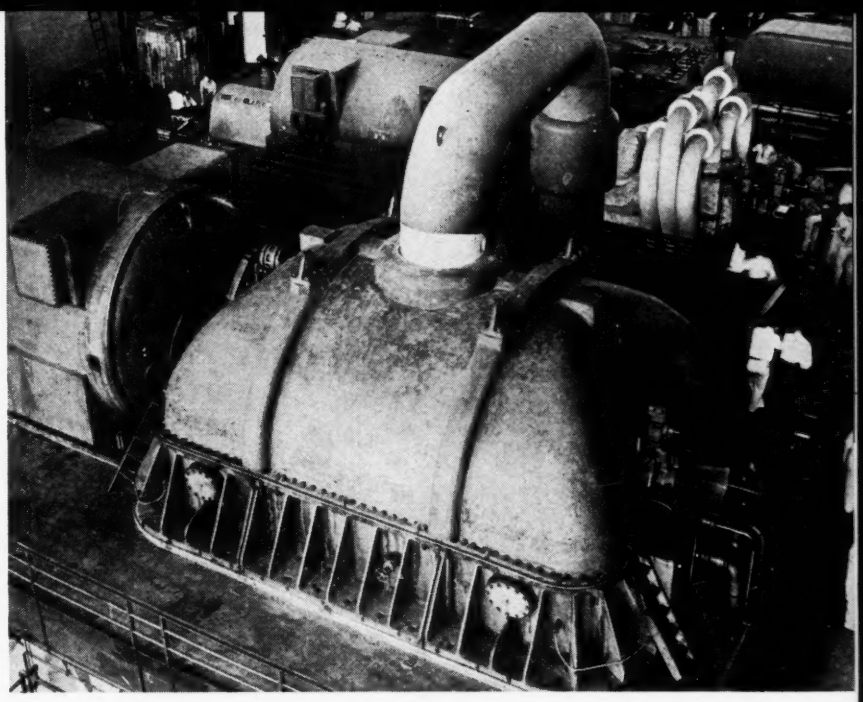


Fig. 2. Initial turbine generator installed in new Southwark Station of Philadelphia Electric Co. consists of a 65,000-kw, 3600-rpm high-pressure unit and a tandem-compound 85,000-kw, 1800-rpm low-pressure unit

There has been much interest in the spreader stoker during the year because of its ability to burn a wide range of coals and its flexibility in operation. Details of these stokers were given in November, 1947, issue.

Since that article was written, another spreader stoker, Fig. 1, has been announced. It incorporates the linkgrate, in two sections, a main or center section and two side or wing areas. The coal is thrown over the central grate by a spreader device. Here it is burned in a thin bed with air purposely inadequate, thus maintaining relatively low combustion gas velocity and less tendency for the fines to be swept up the stack. To complete the combustion of the hot gases, excess air is introduced at the side zones, to meet these partially burned gases with great turbulence.

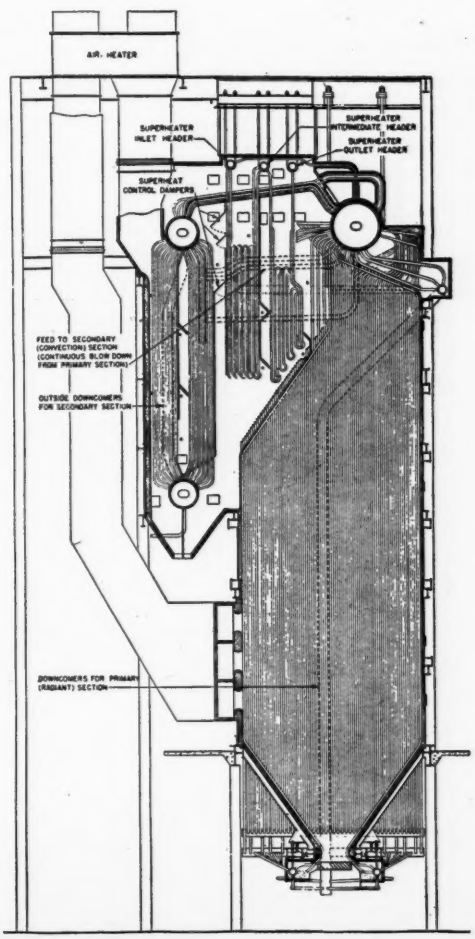

AIR HEATER
SUPERHEATER INLET HEADER
SUPERHEATER INTERMEDIATE HEADER
SUPERHEATER OUTLET HEADER
SUPERHEAT CONTROL DAMPERS
FEED TO SECONDARY (CONVECTION) SECTION (CONTINUOUS BLOW DOWN FROM PRIMARY SECTION)
OUTSIDE DOWNCOMERS FOR SECONDARY SECTION
DOWNCOMERS FOR PRIMARY (RADIANT) SECTION

Fig. 3. Steam generating unit, for high make-up conditions, with dual circulation

(From EEI Publication O-13)

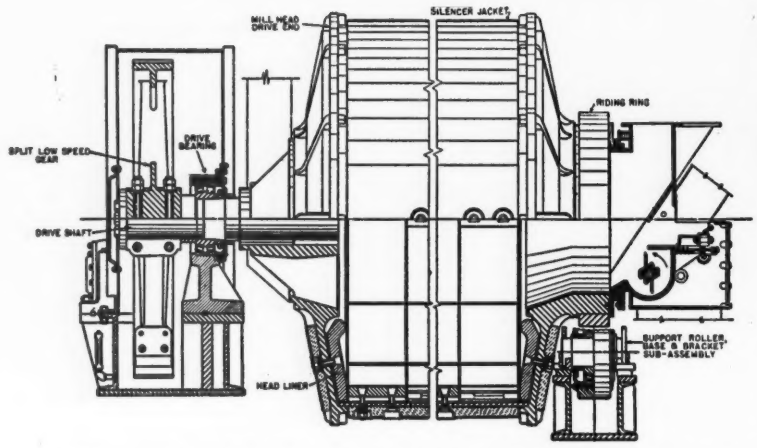


Fig. 4. Diagram of new ball mill, with spreader feeder to distribute coal over length of mill, preventing clogging of wet coal (From EEI Publication O-13)

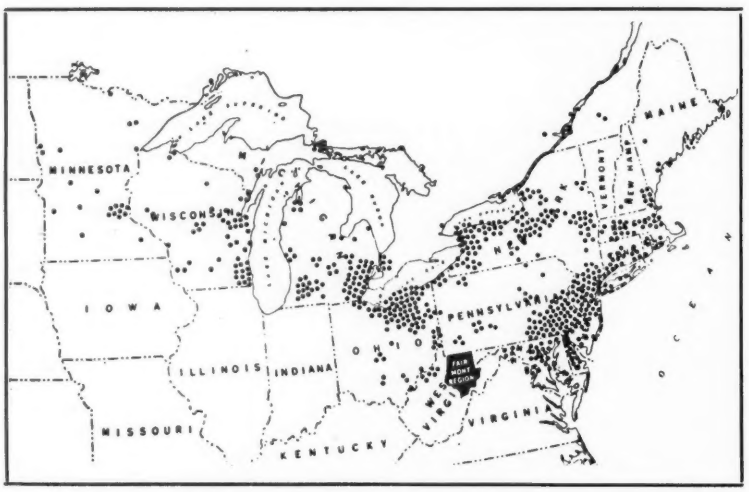


Fig. 5. Map showing location of 600 new steam generating units designed for wide fuel flexibility. (Recorded by Fairmont Coal Bureau)

Table showing distribution of over 600 steam generating installations analyzed by Fairmont Coal Bureau

INDUSTRY CLASSIFICATION

By Types of Firing

	Pulverizers	Spreader Stokers	Traveling Grate Stokers*	Underfed Stokers	TOTAL
Iron and Steel	4	4		2	10
Stone, Clay, Glass and Cement Priducts	3	3		1	7
Food and Kindred Products	6	36		15	57
Chemical and Allied Products	30	28	1	9	68
Paper and Allied Products	33	28	2	16	79
Textiles, Fabrics and Their Products	10	13	1	3	27
Machinery (not including transportation)		5		10	15
Transportation Equipment:					
Automobiles and Accessory Parts	14	29		4	47
Locomotives and Railroad Equipment	3	3	2	1	9
Non-ferrous Metals and Their Products	1	4		1	6
Rubber Products	5	2		3	10
Public Utilities	84	14		2	100
Municipal Utilities	18	17	4	8	47
Leather and Its Manufactures		5			5
U. S. Government		4			4
Building Industry and Materials	8	11		1	20
Distilled Spirits and Brewing	8	4		1	13
Plastics				1	1
Household Appliances and Equipment	2	3			5
Electrical Manufacturing Industry	3	14		4	21
Specialty Manufacturers	1	2			3
Educational Institutions	3	4	2	5	14
Miscellaneous	1	26		10	37
TOTAL	237	259	12	97	605

* Includes Chain Grate Stokers.

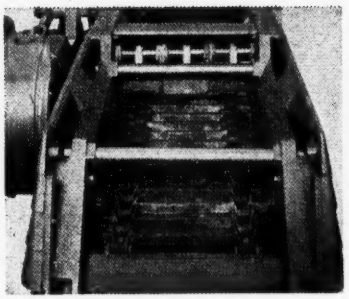


Fig. 6. Chain type feeder for a recent spreader stoker

The grate moves at a very slow rate with small motion, so that the ash and a small amount of unburned coal are gradually worked to the two side grates, which can be dumped at intervals.

Success of overfire air jets in promoting complete combustion and eliminating smoke, especially in locomotives, has led to a vigorous campaign on the part of Bituminous Coal Research, Inc., to extend their use in stationary installations. Full details of their use will be given soon in these pages by Wm. S. Major of BCR.

With the spreader stoker, overfire air jets are especially effective in promoting turbulence and complete combustion. Details of jet construction and location will soon be given in these pages.

Preventing Stack Emissions

Interest in use of fly-ash for use in concrete construction or cinder concrete block and other purposes is increasing. The practices of Detroit Edison Co. in disposing of this fly-ash were detailed in the October, 1947 issue. One company sinters fly-ash to make a lightweight aggregate as a substitute for cinders in concrete.

A new gas scrubber utilizing the venturi principle, is being tried out in full size commercial installations, after exhaustive pilot plant tests, and looks promising.

Use of supersonic vibration for precipitating and collecting dust particles of 10 microns or less in industrial processes (November issue, page 7) is of present interest to power engineers. Many feel it has possibilities in fly-ash elimination. Others are studying its possible effects in improving combustion itself.

For large units burning Midwestern coals, the cyclone burner may lead especially to great reduction in fly-ash emission. It is reported that 80 per cent of the ash is trapped in the molten slag in this burner. It has been so successful that Commonwealth Edison Co. has announced that all future additions to its capacity would be fired by the cyclone burner. Installations of it are being planned for new steam generating units at Fisk Station and the new Ridgeland Station.

Because of the widespread adoption of acid cleaning of boilers and

other power plant equipment, especially with large units, there has been some concern over reports of corrosion in boilers that have been acid cleaned. Surveys were made by the EEI Prime Movers Committee. As reported in its Publication O-13, information received indicates that most users believe they have applied acid cleaning without resultant corrosion. They have sufficient confidence in it and intend to continue using it. A few stations did experience corrosion due to acid cleaning. But they are unable to select any single factor as a positive cause. The information available is too limited for this report to be a conclusive commentary on relation between corrosion and acid cleaning.

Measurement of oxygen in flue gas, with the indicator or recorder calibrated in terms of excess air, is being developed by several manufacturers.

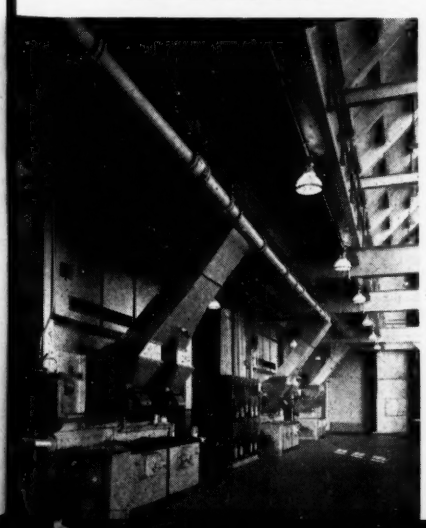
Automatic steam temperature control, electronic type power plant instruments, differential master fuel-air ratio control are some of the recent developments.

Interest is growing in burning of alternate fuels—coal or gas or oil—and simultaneous firing of two fuels, also use of industrial wastes as fuels. A new automatic control combustion corrector is available for use on installations where two or more are burned simultaneously or where fuels of varying heat content are burned.

Methods have been devised whereby an internal combustion engine can burn gas on the Diesel cycle and transfer back and forth from gas to oil very quickly or even automatically. The problems of maintaining the efficiency of this engine at all loads have now been solved by several manufacturers.

As a result of this, Diesel engines can now be installed where there is possibility of fuel shortages or where gas supply is not always available, as in sewer gas installations, or on gas pipe lines, burning oil in winter when gas must be conserved.

Fig. 8. General view of firing aisle, new boiler house, Chevrolet Flint Division, General Motors Corp. (Albert Kahn Associated Architects & Engineers, Inc.)



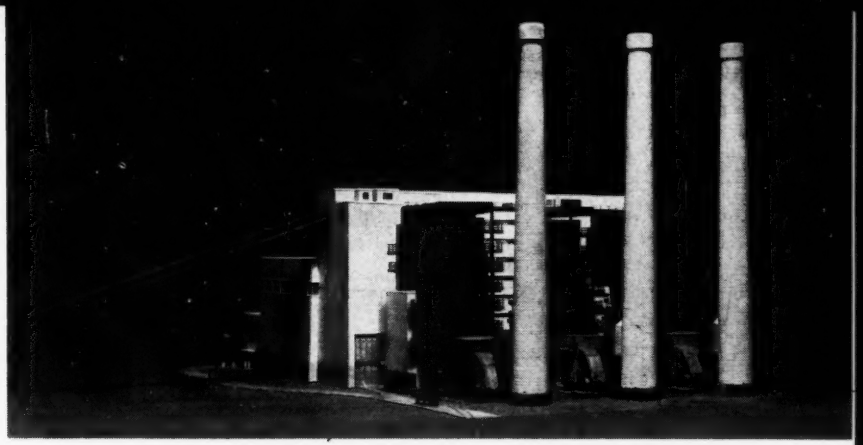


Fig. 7. View of model for Sewaren Station, Public Service Electric and Gas Co., Sewaren, N. J. Three 850,000-lb-per-hr boilers fired by pulverized coal. Steam conditions 1500 psi, 1050 F. Initial capacity 300,000 kw in 3 units. Turbine generators entirely indoors; fronts and part of sides of boiler housed for protection of operators and maintenance crews. About 50 per cent of heat radiating surface of boiler and auxiliaries outdoors. Enclosed area ventilated with 100 per cent filtered air

Electrical Developments

TIME WAS when things were what they seemed; when the universe was circumscribed by the limits man liked to believe existed; when electricity flowed through conductors and when conductors were conductors, and insulators were insulators, when nations believed treaties were things to be adhered to and monetary systems could not exist without a gold standard. There was a time, too, when space and time were absolute, when matter was matter and energy was energy, when Coulomb's law was held universally valid.

But the older we grow, the more do we find that things are not what they seem. As we learn more, our old concepts fall apart. Laws which we knew once were universally valid have to be changed or amended. Things that once were thought impossible become commonplace. Nothing is constant, the one great manifestation of the universe is change.

In no particular branch of human endeavor is this constant change more apparent than in the field of electricity — in what we call the "electrical art." The change and development in every branch of the electrical art is so rapid, so revolutionary, that even the specialists in particular branches of the field have difficulty in keeping abreast of progress.

Who, for example, even ten years ago would have thought of "printed" electrical circuits, "printed" electrical components such as capacitors and resistors. Today such strange things are actually in production. During the war, the National Bureau of Standards and since then, other agencies, developed printed electrical circuits for communication work and now extremely low-loss and high stability capacitors are being produced by similar processes. This process[1] is based on the laying down by spraying, of layers of vitreous enamel alternating with layers of conductive silver paste deposited by silk screen or squeegee printing. The ceramic dielectric has a loss factor of the same order as mica and the properties of the silver are such that high electrical conductivity is obtained. These units can be made very small. A 500 v unit 0.3 in. by 0.3 in. by 0.05 in. has a capacitance of 50 mmf.

To electrical engineers of an older school, a most startling concept is the use of pipes and tubes and fittings for the transmission of ultra high frequency currents. These are the wave guides—the so-called "microwave plumbing" which characterizes radar equipment. Frequencies? Such equipment operates at frequencies so far above anything thought possible ten years ago that the very figures are astonishing—23,000 as high even as 30,000 **megacycles!**

Not only are frequencies of this order produced and controlled by the cavity magnetrons and klystrons, but they are produced at enormous power. Before the war, powers developed at frequencies above 300 or 500 megacycles were measured in fraction of watt, at most watts. Today, frequencies of 10,000 megacycles are produced at **thousands** of **kilowatts!**

The new linear accelerator[2] being built at the Microwave Laboratory

[1] Printed Vitreous Enamel Components. By Bradford, Weller, and McNeight. *Electronics*, December, 1947, p. 106.

[2] Electron Linear Accelerator Demonstrated. *Electronics*, November, 1947, p. 144.

of Stanford University for atomic energy, experiments, is expected to use 1000 megawatts — **one million kilowatts.** What sort of equipment is this, that consumes one million kilowatts? Well, it is not very big—it will be probably 200 ft long and will develop 1000 mev (million electron volts). Of course, actually the accelerator consumes power over only a very small portion of the time it is operating. It is excited for a millionth of a second, 60 times per second. So it is off for 999,940 millionths of each second, and on only 60 millionths of a second. This "pulse" type of operation is typical of many types of radar equipment.

Pulse Transmission

The whole question of "pulse" transmission of signals is extremely interesting and subject to continual development. Progress in the last decade in the technique of transmission utilizing the higher frequencies poses a problem not involved with the lower frequencies: how to take advantage, from a transmission viewpoint, of the fact that much wider band-widths per channel are available than strictly necessary if one considers only the elements of most signals to be transmitted. Such signals include telegraph, telephone, facsimile, broadcast, and television sound channels. As early as 1937 the International Telephone and Telegraph Corp. considered a method of solving problems in this field by the transmission of intelligence by pulses of constant amplitude and duration, the instantaneous amplitude of the voice being translated into a variation of time intervals of successive pulses, the rate of this variation corresponding to the instantaneous frequency of the signal. This method was called pulse time modulation, and since its inception has come into practical use.

In addition to pulse "time" modulation, other types of pulse modulation have come into use. For example, there is pulse amplitude modulation, pulse width modulation, and pulse count modulation. All of these methods are useful, new in concept and have greatly extended the utility of the frequency spectrum.

A startling development in the high frequency transmission of intelligence is the revision of Hartley's law. Hartley's law, that the amount of information that can be transmitted in a given time is proportional to the band width of the circuit, has always seemed an unchallengeable fact of nature. But now comes word that the law is up for revision. W. G. Tulles of MIT's Research Laboratory of Electronics together with Professor Wiener of MIT and C. R. Shannon of the Bell Labs, has proved that the Hartley rule must take into account noise as well as signal. The old law said that the product of band width and time was a constant for a given amount of information. The revised law says that the band-width-time product should be multiplied by $1n\ (1 - S/N)$ where S/N is the signal-to-noise ratio. In a noise-free circuit, this multiplier becomes infinite, so a finite amount of information can be sent in zero time on any old band width. The practical man knows this just ain't so. The rejoinder is that all circuits do in fact transmit noise, so the multiplier is not infinite.

At the present time there are no published references on this subject but several papers are expected in the coming months.

Closely related to this subject is the announcement recently of the Ultrafax system. Developed by RCA and billed as "television for communications" the new system is to operate at 1,000,000 words per minute. The system is based on the fact that each single frame of a television image can be separately photographed at the receiving end. In other words, such a system is capable of handling 108,000 complete facsimile pages per hour.

500,000 Volt Transmission Line

All electrical developments, however, are not in the communications field. The initial operation of a new test power transmission system at 500,000 volts,[3] may sound rather insignificant in comparison with the 100 million volt synchrontrons of nuclear research, yet, the attainment of this voltage represents many years of development, experience and effort. Whether the transmission of electrical energy over longer distances will be by high voltage alternating current or high voltage direct current still is uncertain, but there seems to be no practical difficulty in transmitting current at a half million volts.

Thus far, there has been no particular need for transmitting electrical energy over distances greater than 265 miles (i.e. the Boulder Dam-Los Angeles Lines), but the development of large nuclear power plants in the future may make longer distance transmissions desirable.

Electric generator design has undergone little new development in recent years except in refinement, the use of better materials and in standardization. Considerable progress has been made in the standardization of turbine generators over a wide range of sizes. These standardized units will tend to eliminate, as far as possible, the need for building each turbine generator set as a special "tailor made" unit and to promote "off-the-shelf" purchasing with its attendant savings to both builder and user.

Electronic Exciters for Generators

Considerable new development, however, has taken place in the design of the excitation systems for generators. Studies have shown that the 3600 rpm direct-connected exciter, while performing on a satisfactory level had a poorer availability record than the rest of the turbine-generator unit.

The exciter problem has led to the development of electronic types of exciters. Electronic exciters were first applied to synchronous condensers in 1936 and to a synchronous generator in 1946. They promise to

[3] Half million volt test line energized. POWER PLANT ENGINEERING, November, 1947, p. 72.

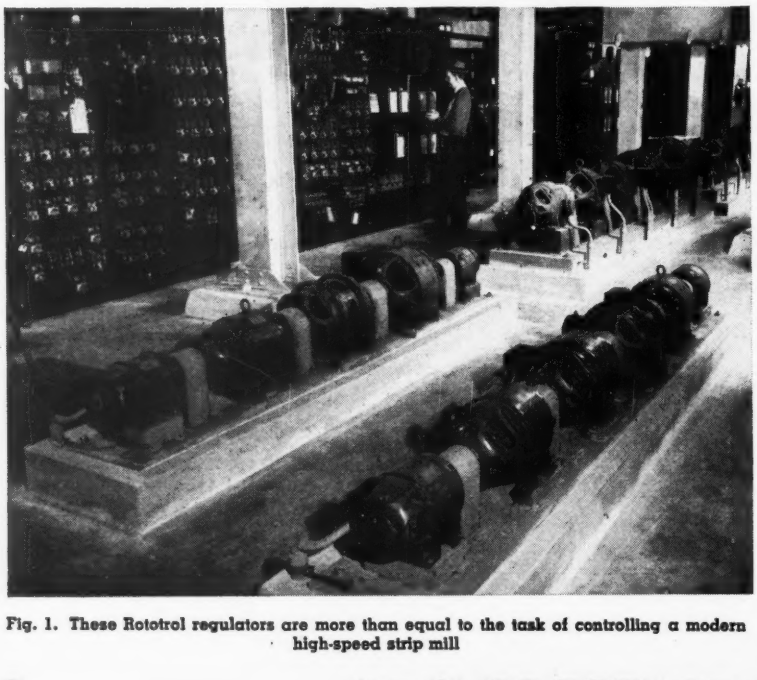


Fig. 1. These Rototrol regulators are more than equal to the task of controlling a modern high-speed strip mill

circumvent the problems of designing large 3600 rpm direct-connected exciters. They offer possibilities of simple operation, low maintenance requirements and high reliability.

New Electronic Stabilizer for Power Transmission Lines

An entirely new concept in the operation of electrical systems is displayed in a test model of a new electronic stabilizer for power transmission developed at the General Electric Co.[4] by Alexanderson and Prince. The limitations of conventional synchronous power transmission are well known. Most long distance transmission lines operate at a load corresponding to surge impedance. This is the loading where the inductance and capacitance of the line neutralize each other so that the voltage remains constant throughout the line. Voltage regulation of an alternator, historically has depended upon variation of the field current, and high speed regulators have been developed to improve synchronous stability.

Now, in the new Alexanderson-Prince system, voltage control is brought about by varying the output current. The system is shown in Fig. 2. A reactive load is connected to the generator terminals. This load is varied electronically in such a way as to maintain the desired voltage and line current. Whereas regulation by field control is limited by the long time constant of the field winding, the electronic stabilizer acts upon the transient reactance and therefore it has the fast response needed to increase the stability of long transmission lines. In its function it is analogous to a synchronous condenser because it is connected by drawing a controllable current from the line.

This system offers a new approach to an old problem—the extension of electric power transmission. It is less radical than d-c transmission. The electronic equipment may be of the type which has been in service for many years in the Carnegie Illinois frequency changer.[5] Of course, there are other methods for extending a-c transmission, such as intermediate synchronous condenser stations and series capacitors and no attempt has been made so far to make an economic comparison of the electronic stabilizer with these older methods. All three differ in principle and they may be used in combination. Whether the new method will compete economically with other methods is for the future to determine.

High Capacity Breakers

In the circuit breaker field, a remarkable feat of the year was the interruption of 7½ million kva by a single breaker. Last spring a Westinghouse circuit breaker of the dead tank easily interrupted short circuits of more than twice the kva rating of any breaker now in service. This was all the energy that all six Grand Coulee generators and six incoming lines solidly tied together could muster.

With power systems growing larger the amount of energy that can be dumped into a single short-circuit is rising steeply. For example, when all 18 of the 108,000 kva generators are installed at Grand Coulee the faults on the 230 kv bus may reach 10,000,000 kva, whereas the largest circuit breakers now installed are rated at only 3,500,000 kva.

To assist in the development of higher capacity breakers, the Grand Coulee power plant was turned into a gigantic high-power laboratory. The entire Bonneville system and Northwest power pool was tied together through six 230 kv transmission lines into the Grand Coulee switchyard and paralleled with all six of the existing 108,000 kva generators. A single pole test circuit breaker with the latest design of multi-flow De-ion gird interrupters was used. In order to squeeze every bit of short circuit energy into the test, the breaker was pre-tripped so that a fault current was established just as the contacts began to separate. Climaxing a group of 15 tests were two tremendous short circuits with the total RMS current reaching 17,800 and 18,200 amp respectively, corresponding to a 3-phase fault of 7,500,000 kva at the bus voltage of 238 kv. All interruptions took place within the rated time of 3 cycles.

It should be obvious to anyone who knows anything about the electrical industry that it is impossible in a few pages to even touch upon all the various developments in the field. The field of electronics alone is so fast that it touches every walk of life—from the roasting of hot dogs by high frequency currents to the operation of the great computing machines being installed in our universities and laboratories. In the so-called memory tubes, we have a device capable of accepting a multiplicity of mathematical data, storing information indefinitely, and returning any part or all of it to the user on demand.

An interesting development of the year was the commercial investigation of the possibility of reflecting microwave radio signals from the moon, along the lines indicated by the Signal Corps experiments announced two years ago, with the hope that long distance communications can be made possible and overcrowding at lower frequencies reduced.

Microwave technique is also being investigated in the field of industrial heating. Methods are being developed for using wave-guides for applying microwave energy to moving or stationary wires and threads, sheets or irregularly-shaped objects to achieve uniform dielectric heating.

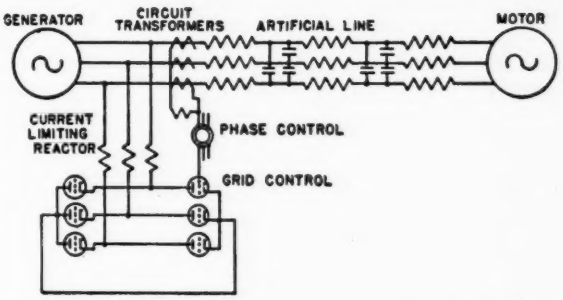


Fig. 2. Electronic stabilizer for power transmission test equipment

Amplifiers and Controls

New possibilities in the field of amplifier design have been developed. Two types of amplifiers have been built for almost completely reducing noise in amplifying circuits. One of these is the dynamic noise suppressor developed by H. H. Scott; the other, a non-linear type of circuit developed at RCA labooratories. These developments make previously useless phonograph records usable again, but more than that, it is of even greater advantage on modern high-quality records, where the noise level is not excessive but still noticeable and annoying.

In the field of measurement and control, the thermistor is meeting with continual increased application. Thermistor is a contraction of the expression, "thermally sensitive resistor," and is one of a class of non-ohmic solid conductors known as varistors. Varistors are semi-conductors whose resistance value varies in response to conditions to which it is subjected in accordance with definite laws. In the thermistor, the conductivity varies as a function of the temperature, in some cases as much as 5 per cent per degree C at room temperature. Small, extremely stable in performance, having a wide range of resistance values, these devices are finding all sorts of applications in the entire field of measurement and control. They will find increasing use in the years to come.

[4] Electronic Stabilizer for Power Transmission, by Ernst F. W. Alexanderson and David C. Prince. *Electrical Engineering*, November, 1947, p. 1053.

[5] History and Development of the Electronic Power Converter, POWER PLANT ENGINEERING, December, 1944, p. 84.

The Gas Turbine in 1947

OUR FOURTH prime-mover, the gas turbine, moved steadily forward during the year. The first marine gas turbine to operate as reported by *The Oil Engine and Gas Turbine*, was a Metropolitan-Vickers 2500-hp unit installed on a gun-boat of the British Navy. It made its first voyage in August 1947; reported fuel consumption a little over 1 lb oil per brake hp hr.

Full details of developments in the gas turbine power plant have been given by John I. Yellott in his series of articles on The Gas Turbine Power Plant published in various issues of POWER PLANT ENGINEERING during 1947, beginning with the January issue.

As Mr. Yellott has pointed out, the fuel reserve situation, as well as the comparative prices of coal and oil, (September, page 113 also this issue), and the increasing use of Diesels by the railroads, have led the Locomotive Development Committee of BCR to embark on the development (headed by Mr. Yellott) of the coal-burning gas turbine locomotive. Various components of these units have been tested, such as the fuel-preparation and transporting systems, the combustors, the control devices, the fly-ash separators. A pilot plant at Dunkirk, N. Y. has been in operation since January 1947.

A full-scale working "mock-up" of the entire coal-handling, combustion and fly-ash separation system is now being operated at Fontana, Calif. where 100,000 cfm of air at 50 psia can be obtained from the blast furnace blowers of the Kaiser Steel Mill (see December, 1945 issue, page 74).

The coal-burning gas turbine may become a reality in 1948 when Elliott Co. expects to deliver a 3750-hp plant and Allis-Chalmers Mfg. Co. a 4200-hp plant, to be installed in locomotives to be supplied by Alco and Baldwin.

General Electric Co. is continuing its development work on a gas turbine unit. The supercharger developments of this company have resulted in many data on metals and operating factors that will prove useful in both locomotive and stationary units.

The Westinghouse 2000-hp experimental gas turbine burning oil, has been put through its paces. No fundamental weaknesses have appeared. By late fall, the unit had run more than 600 hours, including about 100 hours at full load and 300 hours of cyclic operation simulating locomotive service. The machine has operated at the full design temperature, 1350 F, without measurable creep, with no distortion difficulties, without oxidation or any evidence of distress of the K-42-B turbine blade material.

Gas turbine developments in Europe continue at an accelerated pace. Brown Boveri has several units under construction for capacities up to 10,000-kw in single units. Escher Wyss has a 2000-kw closed cycle plant in operation at its plant in Switzerland. Sulzer Bros. are also building a 20,000-kw unit. This unit, as well as a 26,000-kw unit by Brown-Boveri, are designed to back up hydro stations in winter.

A pressure exchanger known as the Comprex (July issue, page 128) developed by Brown Boveri, has permitted a 4000-hp unit to be built only a trifle larger than a 2200-hp unit formerly built for the same service.

The gas turbine has four major potential fields. It may supply: 1—Hot or cold air but no power; 2—Air and power; 3—Power with no utilization of exhaust energy; 4—Power and process heat (discussed in a future article).

Future development of the gas turbine will depend on wise selection of the uses to which the early units are put.

Atomic Energy

WHILE no nuclear power plants are in operation or even contemplated at the present time a vast amount of research and investigation on the development of nuclear energy is in progress. All of this work is being done by private companies and by universities under the direction of the United States Atomic Energy Commission.

The Atomic Energy Commission believes that in the development of atomic energy the participation of the engineering profession must be broadened despite the extraordinary difficulties that secrecy imposes at the present time. As one of several steps in this direction the Commission has recently secured the assistance of an outstanding group of men, who are now examining virtually the entire undertaking and who will make recommendations concerning the ways whereby broader industrial and engineering participation may be secured. This group is headed by the president and general manager of the Detroit Edison Company, James W. Parker.

The development of atomic energy, from ore through production of end products, and including most research and development, is today a business wholly owned by the government of the United States, and is a monopoly by explicit provision of law. This condition is not likely to change in any substantial way, so long as world conditions remain as they are, as a matter of physical fact, not possible of effective separation.

The public is the owner and the boss. And since it is the boss it should be informed. There are two illusions about atomic energy that increase the danger of default by the American people, default in the process of self-education that is at the root of self-government. Both of these can be traced back, in part at least, to the ultra-dramatic way in which secrecy, during the war was ultimately revealed, by the astounding news from Hiroshima. The American people took away two impressions; first, that atomic energy is hopelessly technical and complicated for the average man to understand at all and, secondly, that the whole subject of atomic energy is in its entirety a closely held Military secret, so there is no way the average citizen can become acquainted with it, or with what is going on in its development.

Both of these impressions are erroneous and we shall make no real progress in self-education until these mistaken ideas are corrected. And this is where the role of the engineer comes in; by virtue of his specialized knowledge, the engineer is in a much better position to assimilate the technical aspects of atomic energy than the average citizen and therefore he is in a position to inform his fellow, non-engineer citizens about this new form of energy and also what it means to the human race. This is even a more important function for the engineer than the practical development of atomic energy power plants. As far as the latter are concerned, their future is quite definitely assured; the pattern is set and it is a matter only of technical development. When one considers that 45 tons of uranium 235 which could be represented by a cube 4 ft, 3 in. on a side, could be used to supply all the electric power used in this country for an entire year, there can be little doubt that this form of power plant will be developed.

The PRACTICAL ENGINEER

DEVOTED TO PLANT OPERATION and MAINTENANCE

A. W. KRAMER, EDITOR

☆

WHY NOT MIRRORS ALONE?

About a year ago when a television system was installed in one of New York City's large central stations for the purpose of monitoring the water level in the tall high pressure boilers, those of us, versed in the art of electronics were skeptical of this particular application of television. It seemed some what silly to install a complex electronic equipment involving a score or more tubes simply for the purpose of reading the water level. It was pointed out that there were simple and effective remote water level indicators on the market which would provide the necessary information just as well as the more complex television equipment. ELECTRONICS published an editorial on the subject, and we, quite agreed with it. The comment stirred up such a vigorous defense of the method, however, that it seems now that the use of television systems can be justified for this purpose. As pointed out in another recent editorial in ELECTRONICS, a television system, for all its complexity and need for careful maintenance, has one compelling advantage as a monitor: it cannot give a wrong answer. The television picture either shows the water level correctly as revealed in the gage glass, or it shows nothing at all. If the television system is backed by a system of mirrors which will permit an alternative method of monitoring to be used on short notice, the television system interposes no danger. Other, simpler systems of monitoring are not similarly foolproof. So, as ELECTRONICS puts it a television system, plus a quickly available backstop, is a good answer to a vexing problem.

There is, however, one question we would like to ask, and that is: Why, if a system of mirrors is provided, is the television system necessary?

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A Section of Power Generation
TECHNICAL PUBLISHING COMPANY
53 WEST JACKSON BLVD., CHICAGO, ILL.

How to Select and Apply Centrifugal Pumps

How to calculate the total dynamic head and the quantity of liquid needed per unit of time. The two factors of importance that govern centrifugal pump selection

By TYLER G. HICKS, *Hicks Associates*

POWER PLANT ENGINEERS are frequently called upon to select a pump for a given set of conditions. The calculations necessary to determine which pump should be used are so simple that every plant engineer should be familiar with them. A small amount of study will enable any operating man to become proficient in the selection and application of all types of centrifugal pumps.

All pumps supply energy to the liquid passing through them. This energy is necessary to cause the liquid to flow from a reservoir at a low level to one at a higher level. It is also needed to cause a liquid to flow from a region of low pressure into one of higher pressure. An example of the first condition is the pumping of condensate from a receiver in the engine room up to a feed-heater ten or twenty feet above the receiver. In the second condition a boiler feed pump takes water at low pressure and discharges it into a boiler which is generally operating at a higher pressure. In both instances several important factors concerning pump choice are known.

The two factors which govern centrifugal pump selection are the total dynamic head against which the pump operates and the quantity of liquid needed per unit time. In order to understand the first factor, several terms must be defined.

Total dynamic head is the sum of the static discharge head, friction head, velocity head, and the static suction lift. In general, the term **head** is defined as the vertical distance between two levels of the same liquid. Head is always expressed in feet of the liquid being used. Since a column of liquid will exert a pressure at its base, the term **pressure head** is sometimes used in place of **head.** Pressure head is generally expressed in pounds per square inch or pounds per square foot. Figure I shows several examples of head.

Pressure and head can be readily converted from one to the other. For water at temperatures up to about 100 F,

$$H = 0.433\ p$$
$$p = 2.31\ H$$

where H = head of water ft
p = pressure psi

Static discharge head, H_d, is the vertical distance between the center line of the pump shaft and the free surface of the liquid in the discharge tank. Static suction lift, H_s, is the vertical distance between the centerline of the pump and the surface of the liquid in the suction tank. This term is used when the supply level is below the centerline of the pump. Figure I shows examples of suction lift and static suction head. The latter exists when the supply tank level is above the pump centerline. Static head is the sum of the static discharge head and the static suction lift, $H_d + H_s$.

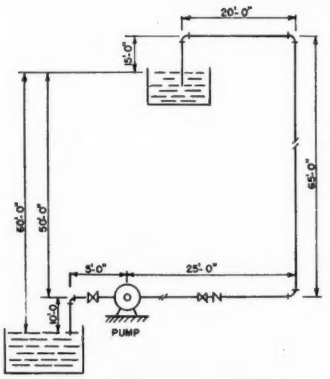


Fig. 2. Pump arrangement for example problem

Friction head, H_f, is the pressure which is required to overcome the resistance of the piping and valves in the suction and discharge lines of the pump. Table I gives friction heads for various sizes of straight pipe with different flow rates. Note that this is the head lost per 100 ft of straight pipe.

Ordinarily suction and discharge pipes contain several bends and valves. The resistance of these fittings is generally different from that of a piece of straight pipe of the same length. After considerable experiment, valve manufacturers have compiled tables listing the resistance of various fittings. These tables express the resistance of fitting in terms of an equivalent length of straight pipe. Thus Table II, a 6-in.

Table I

FRICTION HEADS: Loss in feet/100 feet of straight pipe

U. S. Gals. Per Min.	3" pipe Velocity Head, Feet	3" pipe Head Loss in Feet per 100 ft	4" pipe Velocity Head, Feet	4" pipe Head Loss in Feet per 100 ft	6" pipe Velocity Head, Feet	6" pipe Head Loss in Feet per 100 ft	8" pipe Velocity Head, Feet	8" pipe Head Loss in Feet per 100 ft
100	0.32	4.96	0.10	1.22	0.02	0.17	....	....
140	0.63	9.2	0.20	2.28	0.04	0.32	....	....
180	1.04	14.8	0.33	3.61	0.07	0.50	....	....
220	1.55	21.3	0.49	5.2	0.09	0.73	0.03	0 18
260	2.16	29.1	0.69	7.2	0.13	1.00	0.04	0.25
300	2.88	38.0	0.91	9.3	0.18	1.30	0.06	0.32
400	5.11	65.0	1.62	16.0	0.32	2.20	0.10	0.54

Figures 1a, b, c, d, e. Pump arrangements with various suction lifts and discharges. In all but Fig. 1e the level in the tanks is assumed constant

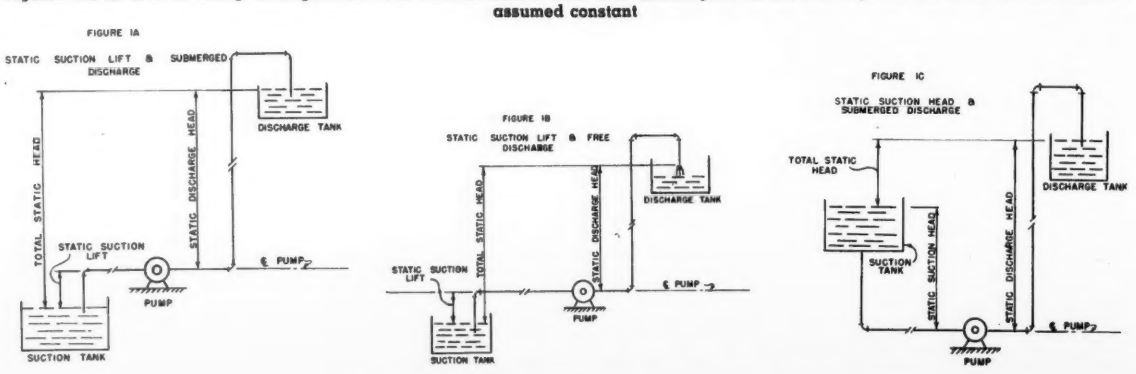


Table III

CENTRIFUGAL PUMPS

Gals per Min.	Total Dynamic Head, Feet of Water				
	90	100	110	120	130
200	D-1	ED-1	L-1	LD-1	LE-1
225	D-2	ED-2	L-2	LD-2	LE-2
250	D-3	ED-3	L-3	LD-3	LE-3
275	D-4	ED-4	L-4	LD-4	LE-4
300	D-5	ED-5	L-5	LD-5	LE-5
325	D-6	ED-6	L-6	LD-6	LE-6
350	D-7	ED-7	L-7	LD-7	LE-7

This table is based on clear cold water. The maximum allowable suction lift is 15 ft.

Fig. 3. Typical bid specification

Specification for Motor Driven Boiler Feed Pump

Capacity ..... 200 gpm
Water Temperature ..... 240 F
Delivery head at pump discharge ..... 1255 ft
Positive head at pump suction ..... 45 ft
Net dynamic head ..... 1210 ft
Current for motor, 3 phase, 60 cycle, 440 v
Include push button reduced voltage starter
Pump to be all ferrous construction for alkaline feed water
Pump and drive to be mounted on cast iron base with drain connections
While any equivalent makes will be given all consideration and may be acceptable, the following are preferences due to existing equipment:
Motor: Crocker-Wheeler
Pump: Double suction type

elbow is equivalent to eighteen feet of straight pipe.

Velocity head, H_v, is the pressure required to accelerate the liquid in the discharge pipe. If the velocity is known, the velocity head may be computed by use of the following relation:

$$H_v = \frac{v^2}{2g}, \text{ where}$$

H_v = velocity head, feet

v = velocity in pipe, feet per second

g = acceleration due to gravity = 32.2 feet per second^2 (approximately)

ft of straight pipe, and a 4-in. gate valve is equivalent to 4.2 ft of straight pipe.

Therefore, $H_s = 10 + 5 + 5.5 + 4.2 + 24.7$ or 25 ft.

Discharge line: From Table II, since there are three elbows in the line, a gate valve, a check valve, and 105 ft of straight pipe,

$H_d = 3(4) + 3 + 24 + 105 = 144$ ft

Friction head in the 25 ft of 4-in. suction line:

$$H_{fs} = \frac{9.3}{100} (25) = 2.32 \text{ ft}$$

Friction head in the discharge line:

$$H_{fd} = \frac{144}{100} (38) = 54.6 \text{ ft}$$

Table II

EQUIVALENT RESISTANCES OF FITTINGS IN FEET

Size of Pipe, inches	3	4	6	8
Standard Elbow	8	11	18	24
Long-radius Elbow	4	5.5	9	13
Globe and Check Valves	24	32	52	75
Gate Valve	3	4.2	7	10

Table I gives velocity heads for various flow rates.

Pump manufacturers generally list centrifugal pumps in a table similar to Table III. Study of this listing reveals that the total dynamic head and capacity must be known before a unit can be selected. In order to illustrate the application of the foregoing principles, a typical pumping problem is given below.

Example: Three hundred gallons per minute of clear cold water must be supplied to the overhead reservoir in Figure 2. Use 4-in. suction and 3-in. discharge lines. Compute the total head on the pump and select a suitable unit.

Solution:

Static head: From sketch, $H_d + H_s = 50 + 10 = 60$ feet.

Suction line: From Table II, a 4-in., long-radius elbow is equivalent to 5.5

Velocity head: From Table I, for the 3-in. discharge line,

$H_v = 2.88$ ft

Summarizing these results in a table, the following is obtained:

	Feet
1. Static head	60.00
2. Friction head	
(a) Suction	2.32
(b) Discharge	54.60
3. Velocity head	2.88
Total dynamic head....	119.80 ft

From Table III, a pump of type LD-5 should be used. The table states that these pumps should be used with a suction lift of not more than 15 ft. Therefore, the suction lift must be checked separately to see that it does not exceed this value.

Suction lift:

	Feet
(A) Static lift, H_s	10.00
(B) Friction, 25 ft of 4-in. pipe	2.32
(C) Velocity head	0.91
Total suction lift.....	13.23 ft

Thus this pump is suitable.

A summary of this method will be helpful.

(A) Make a sketch of the proposed installation. Include all heads and dimensions.
(B) Determine the amount of liquid required in gallons per minute.
(C) Compute the static head.
(D) Compute the static suction lift or head including all bends, valves, and straight pipe.
(E) Compute the static discharge head.
(F) Compute the friction head in the suction and discharge lines.
(G) Compute the velocity head in the discharge line.
(H) Select the pump.
(I) Check the suction lift against that given in the pump catalog.

It should be noted that if the suction tank is above the pump centerline, the static head is the **difference** between the static discharge head and static suction head. See Figure 1-D.

Determination of the quantity of liquid required sometimes presents a problem. However, a little thought will show that the solution is not too difficult.

Consider those pumps which are to handle water. If the unit is to be used to feed an HRT boiler, the problem is simply one of determining the rate of evaporation in the boiler. The same procedure would be followed for a larger watertube unit. Condensate pumps require more lengthy calculations. The amount of condensate to be handled would have to be determined by use of flow quantities for the entire plant. An overall picture of the problem must be obtained. Once this has been done, the calculations are relatively simple.

After selection of a pump, an analysis of its suitability must be made. This analysis will generally include such factors as (a) efficiency, (b) power required, (c) space requirements, and (d) capacity. These factors vary so widely from plant to

FIGURE 1D

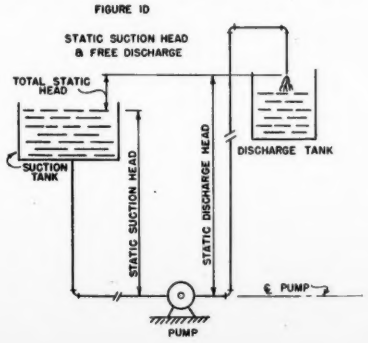
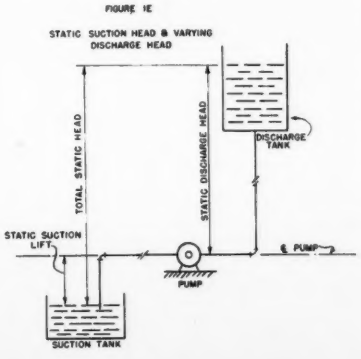


FIGURE 1E



pump which provides the most suitable combination of all should be selected.

When ordering the unit be certain to provide the manufacturer with complete data. A suitable sketch will often be helpful. Figure 3 shows a typical bid specification for a motor driven centrifugal boiler feed pump.

A thorough study of the methods given in this article will help in the selection of any centrifugal pump. Further study of pump catalogs and hydraulic data will result in a good comprehension of all types of pump problems.

Diesel Fuels

Fuel oil characteristics . . . Heating value . . . Viscosity . . . Ignition quality or cetane . . . Diesel index . . . Solid impurities . . . Gravity . . . Flash point . . . Carbon residue . . . Pour point . . . Fuel caused engine troubles

(Ed. note: This is the second of four articles on Diesel engines. The succeeding two articles will deal with lubrication and plant layout and maintenance.)

WHEN Dr. Rudolf Diesel developed the engine bearing his name, he was seeking to develop an internal combustion engine that would operate with pulverized coal as a fuel. He never succeeded in this attempt and had to revert to oil as a fuel, although experiments are being carried on today to develop the coal-burning engine.

Modern Diesel fuels consist of a wide range of petroleum oils; either crude oil direct from the ground, some of the lighter residual oils from the distillation process, or a blend of the two.

Vegetable oils, such as the products from the soy bean, coconuts, peanuts, cottonseed, etc., have been successfully used in Diesel engines, but at present cannot compete with mineral oils. In tropical countries where the price of these oils would be low, their use should become quite practicable providing engines are designed to operate at the higher ignition temperatures of these oils.

Many characteristics of fuel oils must be considered in selecting and specifying Diesel fuels, and Table I lists a number of these characteristics with brief definitions. Each will be discussed briefly in the ensuing paragraphs.

Fuel specifications are based on higher heating values, and the range for Diesel fuels is between 18,000 and 20,000 Btu per lb. Heating values vary with specific gravity, and the ASME uses the following formula for estimating the higher heating value when the specific gravity is known: H = 17,680 60 × deg Baumé.

Viscosity is measured by the length of time, in seconds, required for a given sample of the oil to flow through an orifice at a specified temperature, usually 100 F. It determines the fluidity of the oils and gives a good indication of how readily the fuel will atomize. If an oil with a high viscosity is used it often becomes necessary to heat it in order that the fuel injection system can handle it more easily.

Table I. Diesel fuel oil characteristics

Heating Value—A measure of the energy content of the fuel, expressed in Btu per lb.
Viscosity—A measure of the fluidity of the oil, expressed in seconds, Saybolt Universal, at some specified temperature, usually 100 F.
Ignition Quality—A measure of the ability of the fuel to ignite spontaneously in the combustion chamber, represented by Cetane Number or Diesel Index.
Solid Impurities—Ash and asphalt content, expressed in per cent by weight. These impurities cause cylinder wear.
Water and Sediment—Expressed in per cent by volume.
Gravity—Specific gravity expressed in degrees Baumé or API.
Flash Point—An indication of the inflammability of the oil, expressed in degrees F. Important only in storage precautions.
Carbon Residue—An indication of the amount of carbon residue which may be left in the cylinders, per cent by weight.
Sulfur and acid—Properties causing corrosion, expressed in per cent by weight.
Pour Point—The lowest temperature at which a particular oil will flow, expressed in degrees F.

Ignition Quality

Ignition quality is a predominant factor affecting fuel oil selection. In measuring this characteristic an arbitrary scale of ASTM cetane number is used. Normal cetane has a rating of 100, and alphamethyl naphthalene a rating of zero. The fuel to be tested is used in a special engine running under certain specified conditions, and performance data recorded. Then the same engine is run on a mixture of calibrated reference fuels until the performance characteristics of the test fuel are bracketed, the mixture re-proportioned, and the engine run again until performance characteristics similar to those of the test fuel are obtained. Since the cetane numbers of the reference fuels are known, and the proportions of each carefully noted, the cetane number of the test fuel is easily determined.

Another method of rating the ignition quality of Diesel fuel is that of the Diesel Index, which is calculated as follows:

$$\text{Diesel Index} = \frac{\text{Aniline point (Deg F)} \times \text{API Gravity}}{100}$$

The aniline point is determined by heating a mixture of equal volumes of aniline and the sample of fuel oil in a jacketed test tube to a clear solution and then noting the temperature at which turbidity appears on cooling. The higher the Diesel index the better the fuel, other things being equal. Table IV shows an approximate conversion from Diesel Index to Cetane number.

Solid Impurities

Ash and asphalt content should be negligible in fuel oils which are suitable for use in Diesel engines. When present, these particles mix with the

Table II. ASTM Diesel fuel oil classification (1941)

Grade of Fuel	1-D	2-D	3-D	4-D
Viscosity, Saybolt Universal,				
@ 100 F, Min	...	32.6	...	...
@ 100 F, Max	...	45.5	65	140
Pour Point, Deg. F, Max	0	20	35	35
Cetane Number, Min	50	45	35	30
Flash Point, Deg. F, Min	100	140	140	140
Carbon Residue, per cent by wt., Max	...	0.20	1.0	3.5
Ash, per cent by wt., Max	0.01	0.01	0.02	0.05
Sulfur, per cent by wt., Max	0.5	1.0	1.5	2.0
Water and Sediment, per cent by vol., Max	0.05	0.05	0.1	0.5
Distillation:				
90 per cent deg F, Max	...	650	...	...
End point, deg. F, Max	590	700	...	...

Table III. ASTM Diesel fuel oil recommendations

Grade	Type of Engine
1-D	Solid injection engines operating over 1000 rpm.
3-D	Solid injection engines operating from 360-1000 rpm.
4-D	Air injection engines operating under 400 rpm; solid injection engines with cylinder diameters over 16 in. when operating under 240 rpm.

lubricating oil and form an emulsion much like lapping compound, causing cylinder wear.

These impurities will damage the fuel injection pumps and nozzles, and as a result must be kept at a minimum. Water enters the fuel as a result of moisture condensing from the air above the fuel in the tank or from careless handling. Fuels with a lower viscosity will allow the water to settle out rapidly whereas the more viscous residual fuels will hold water in suspension for long periods.

At one time specific gravity was thought to be so important that practically all fuels were purchased on a gravity basis. At present this quality serves little purpose other than as a means of estimating specific heat as shown above.

Maximum economy will usually be obtained from fuels having a gravity between 22 and 28 API. Economy suffers on heavier fuels because the combustion efficiency is decreased and on lighter fuels because the heating value is less.

This characteristic is important only as it is related to fire hazard, and specifications vary with state fire laws.

Carbon residue should be low to reduce carbon deposits, particularly coking in the injector, which seriously affects the fuel spray. High carbon residue is an indication that the fuel has not been completely distilled, and such residual oils must be carefully tested for sediment. They do not burn as cleanly as distillate fuels, but they usually are cheaper, and often in the long run may prove to be more economical despite increased maintenance costs and less satisfactory operation.

High sulfur content is objectionable since it causes engine deposits and corrosion and increases wear rates. Small percentages have no affect on performance.

Pumping and handling in cold weather will be affected by the pour point, and distillate fuels usually have a pour point low enough so that the oil will flow at the lowest temperature at which the engine can be started. Pour point depressors can be added which will prevent the wax crystals in the oil from congealing and thus lower the pour point. Heavy oils may not flow because the viscosity increases with the decreased temperature, and depressors would be of no avail, since the decreased fluidity is a result of increased viscosity and not of the wax crystals congealing.

Table IV. Approximate Conversion Table Diesel Index to Cetane Number

Diesel Index	Cetane Number
0	18
5	20
10	24
15	28
20	30
25	34
30	37
35	40
40	43
45	46
50	50
55	53
60	56
65	59
70	62
75	65
80	68
85	71
90	75
95	78
100	81

Many types of engine trouble can be traced directly to the fuel used, and a brief list of common engine difficulties which can be attributed at least partially to improper fuel follows:

BEARING WEAR—Can be caused by sulfur or water in the fuel.

CYLINDER WEAR—Can be caused by abrasive material in fuel, water in fuel or corrosive fuel.

HIGH OIL TEMPERATURE—Late burning of fuel.

CRANKCASE DEPOSITS—Carbon from partly burned fuel.

COMBUSTION CHAMBER DEPOSITS—Sediment from fuel, fuel carbon.

RING STICKING—Carbon from fuel.

POOR COMBUSTION—Improper injection because fuel viscosity is too low, water and sediment in fuel; carbon in injector from improper fuel; cetane number too low, improper viscosity, high residue.

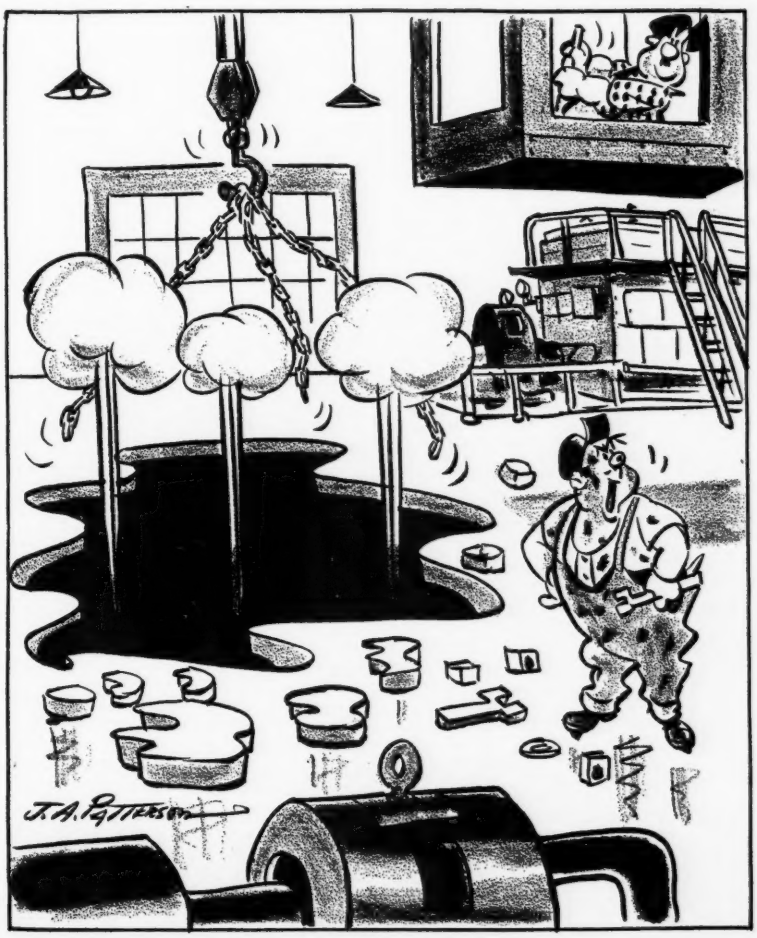
COMBUSTION NOISE — Low cetane fuel.

LACK OF POWER—Low heating value of fuel.

Summary of Diesel Fuel Requirements

To summarize briefly, the requirements of a Diesel fuel are:

HEATING VALUE — Higher heating



"BUTTERFINGERS"

value should be between 18,000 and 20,000 Btu per lb.

VISCOSITY—Should be correct for atomization and penetration requirements of the combustion chamber, low enough to flow freely at lowest temperatures and high enough to lubricate the injection system and prevent leakage.

CETANE NUMBER—Sufficiently high for satisfactory starting and proper combustion.

SOLID IMPURITIES—Minimum.

WATER CONTENT—Minimum.

GRAVITY—Should be between 22 and 28 for maximum economy, although this requirement should be waived to secure fuels with desirable viscosity and ignition quality.

FLASH POINT—Above legal requirement for safety.

CARBON RESIDUE—Minimum.

SULFUR AND ACID—Minimum.

POUR POINT — Below lowest temperature encountered.

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Flow of Fluids

Eleven equations for use in pipe work to help you determine: velocity, pressure drop, rate of flow, laminar and turbulent flow, absolute and kinematic viscosity . . . Use of the Reynolds number in flow work calculations for any fluid through any pipe; to determine the friction factor . . . The Fritzsche formulas for air and steam . . . The Unwin-Babcock formula for flow of steam

By W. A. HYNES

FLUIDS are used in all power plants. Without their use the conversion of heat energy to electrical energy would be impossible. Since both design and operating engineers are constantly dealing with the flow of fluids, this article will attempt to explain and illustrate the various principles which govern their flow.

The term *fluid,* as used in power plant work, includes water, air, steam, ammonia, oil, brine, and several others of lesser importance. Facility in computing the rate of flow and pressure drop from one point to another in a pipeline or channel is needed by all engineers.

Determination of the rate or velocity of flow of the fluid, or the area of pipe necessary may be made by the application of a simple relation known as the continuity equation.

$$w = \frac{vA}{V} \qquad \text{Eq. I, where,}$$

w = flow rate, pounds per second
v = velocity of fluid, feet per second

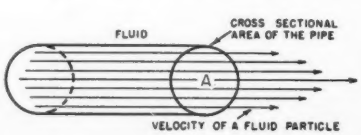


Fig. 1. Continuity equation factors

A = internal area of pipe, square feet
V = specific volume of fluid, cubic feet per pound

Figure 1 shows two of the factors in this equation. The other two cannot be shown graphically.

The Continuity Equation states that the weight of fluid flowing per unit time is equal to the product of its velocity and the area of pipe, divided by the specific volume of the fluid at the section of the pipe under consideration. If any three of the quantities in this equation are known, the fourth can be found by transposing the equation and inserting the known values. Thus,

$$v = \frac{Vw}{A} \qquad \text{Eq. II}$$

$$A = \frac{Vw}{v} \qquad \text{Eq. III}$$

$$V = \frac{vA}{w} \qquad \text{Eq. IV}$$

These four equations provide a useful tool for the solution of many types of flow problems. A typical problem using the above relations is given below:

Example: Ten thousand pounds of dry saturated steam per hour flow through a 4-in. standard pipe at 135.3 psig. What is its velocity?

Since the velocity is the unknown quantity, Equation II should be used. Care must be taken to use the correct units. Convert pounds per hour to pounds per second by dividing by 3600. With the aid of a steam table, determine the specific volume at 150 psia. From a table of pipe properties the internal transverse area of a 4-in. standard pipe can be found. Then

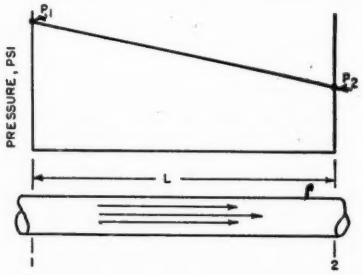


Fig. 2. Pressure loss in a horizontal pipe

$$v = \frac{Vw}{A} \qquad \text{Eq. II}$$

$$= \frac{3.02 \text{ ft}^3/\text{lb} \left(\frac{10{,}000 \text{ lb/hr}}{3600 \text{ sec/hr}}\right)}{\frac{12.7 \text{ sq in.}}{144 \text{ sq in./sq ft}}}$$

$$= 95.2 \text{ ft per sec or } 5700 \text{ ft per min}$$

This is a reasonable velocity for saturated steam. By reasonable is meant that it has been used successfully in many plants.

Table No. I shows typical velocities of several fluids used in power plant work. This table is valuable when the actual velocity in a pipe is unknown. A mean value can be selected and used in the solution.

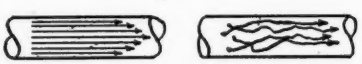


Fig. 3. Left. Laminar flow showing parallel paths of fluid particles. Fig. 4. Right. Turbulent flow showing non-uniform paths of fluid particles

Thus an approximation of the rate of flow, area of pipe necessary, or specific volume may be obtained although the exact velocity is unknown. Thus, if a pipe is to be installed for temporary steam or water supply, the required size can be readily determined. With the use of other relations, the pressure drop in the line may also be determined.

When a fluid flows through a pipe or duct, there is always a change in pressure. The change is generally a decrease because energy is required to overcome the frictional resistance of the pipe or duct.

For short horizontal pipes through which any fluid flows without changing its density more than about ten per cent, the following relation is valid for pressure drop.

$$P_1 - P_2 = f\frac{L}{D} - m\frac{v^2}{2g} \qquad \text{Eq. V, where}$$

Table Showing Typical Fluid Velocities Used in Power Plants

Fluid	Gage Pressure psi	Service	Velocity, fpm
Water	20 to 50	City Water	120 to 300
Water	50 to 150	General	300 to 600
Saturated Steam	0 to 25	Heating	4,000 to 6,000
Saturated Steam	25 up	Miscellaneous	6,000 to 8,000
Superheated Steam	250 up	Turbine and boiler leads	10,000 to 15,000
Air	0	Industrial buildings	800 to 1,800

P_1 = pressure at point 1, pounds per square foot
P_2 = pressure at point 2, pounds per square foot
f = friction factor for the pipe
L = length, feet
D = internal diameter, feet
m = density of fluid, pounds per cubic foot
v = velocity, feet per second
g = 32.2

Figure 2 shows to an exaggerated scale the pressure drop which takes place in a pipe line. The average density of the fluid is generally used in this relation.

For longer pipes through which a gas or vapor is flowing, the pressure drop may be determined by the following relation.

Equation VI

$$P_1^2 - P_2^2 = \frac{w^2 RT}{ga^2}\left[f\left(\frac{L}{D}\right) - 2 ln \frac{v_2}{v_1}\right]$$

Symbols are the same as before. The additional symbols are:

R = gas constant, 53.3 for air
T = absolute temperature R — deg F — 460
a = transverse area of pipe, square feet
ln = logarithm to base e
v_1 = velocity at section 1, feet per second
v_2 = velocity at section 2, feet per second

To use this and the former equation, the value of f must be known. It can be found by use of the Reynolds Number which will be explained later in this article. Equation VI can be used only for gases and vapors which obey the perfect gas law $PV = wRT$. It is seen that use of the relation is limited because air is the only power plant fluid which follows this law. Steam does not. Hence other means must be used to determine the pressure drop in a steam line of greater length.

Before showing the newer means of determining pressure drops, two types of fluid flow should be defined and explained.

In laminar or viscous flow, each particle of the fluid moves in a direction parallel to the motion of every other particle (Fig. 3). Laminar flow takes place at very small velocities and is seldom encountered in power plant work.

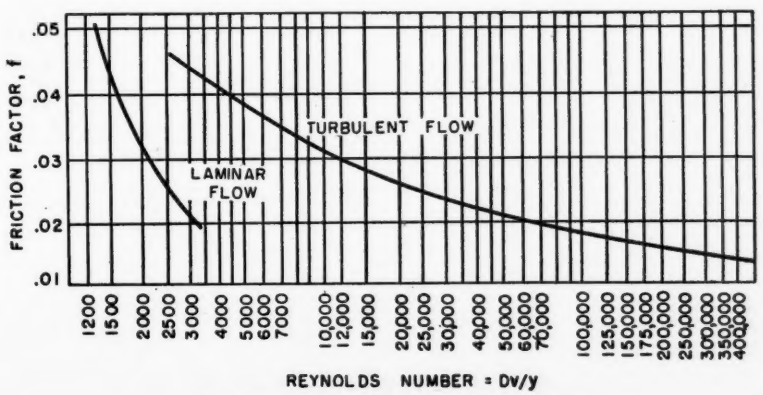


Fig. 5. Reynolds number versus friction factor

Turbulent flow is non-viscous flow, and is characterized by rapid changes in direction of a fluid particle as it proceeds through the pipe (Fig. 4). To relate these two types of flow a quantity known as the Reynolds Number is used.

The Reynolds Number is a criterion of flow. For *any* pipe with *any* fluid flowing through it, a value of the Reynolds Number will show what type of flow is taking place and the friction factor for the pipe. Study of Fig. 5 shows that for values of the Reynolds Number between 1200 and 2000, laminar flow is present in any pipe with any fluid. Between values of 2000 and 3000 the flow is changing from laminar to turbulent. Values in this region are called critical because of this change. Above 3000 the flow is always turbulent.

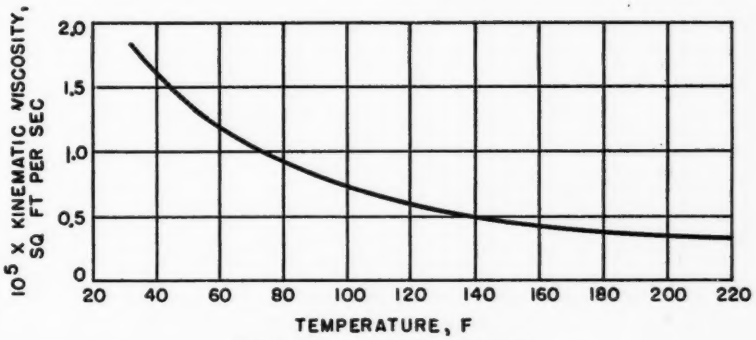


Fig. 6. Kinematic viscosity of water

It will be noted that when the Reynolds Number is stated it is a pure numeric not having dimensions. This means that regardless of what system of units are in use the number will always be the same for the same fluid.

In equation form the Reynolds Number is stated as follows:

Equation VII

$$R = \frac{Dvm}{u} = \frac{\text{(diam.) (veloc.) (dens.)}}{\text{absol. viscos. of fluid}}$$

Equation VIII

$$= \frac{Dv}{y} = \frac{\text{(diameter) (velocity)}}{\text{kinematic viscos. of fluid}}$$

In these equations D is in feet, v in feet per second, y in square feet per second. Since use of the kinematic viscosity simplifies the calculation of R, it will be used here and the absolute viscosity neglected. A study of equations VII and VIII will show, however, that the kinematic viscosity is equal to the absolute viscosity divided by the density of the fluid. Figures 6, 7, and 8 give the kinematic viscosities of water, gases, and steam in square feet per second. Fig. 9 gives the relation between viscosity in Saybolt seconds and kinematic viscosity.

Referring back to Fig. 5, it can be seen that with a known value of Reynolds Number, the value of the

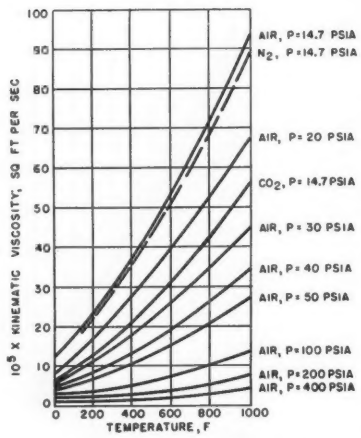


Fig. 7. Kinematic viscosity of gases

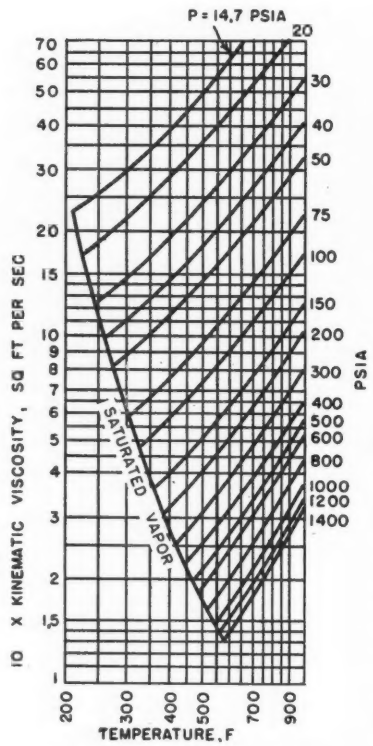


Fig. 8. Kinematic viscosity of steam

fraction factor in a pipe can be determined. For instance, if R = 30,000, f = 0.025 for *any* fluid. From this it can be seen that the number can be very useful. Its use is not limited to air or water. *Any* fluid may be used.

By use of the continuity equation, Reynolds Number, and the long or short line equation, a variety of flow problems can be solved. To further increase the utility of this method another equation for the pressure drop will be given. It may be used for any fluid.

Equation IX—Symbols as Before

$$P_1 - P_2 = f\left(\frac{L}{D}\right)\left(\frac{v^2}{2gV}\right)$$

Using this relation or the long or short line formulas permits the solution of any pipe line problem.

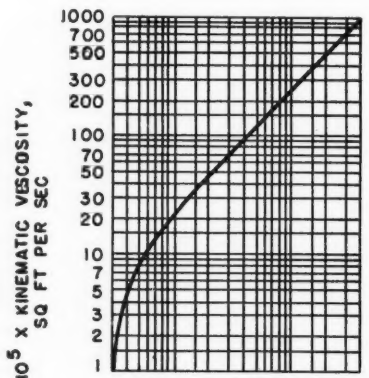


Fig. 9. Relation between kinematic viscosity and saybolt seconds viscosity

Frequently the value of the Reynolds Number exceeds those given in Fig. 5. For this reason Figs. 10 and 11 are given. A typical problem using this method follows.

Example: A new horizontal 12-inch steel pipe has 360,000 pounds of steam flowing through it per hour. The steam pressure is 350 psia, and the temperature is 500 degrees F. Find the drop in pressure per 100 feet of pipe.

Solution: Rate of flow $= \frac{360{,}000}{3600}$

$= 100$ pounds per second.

Area $= 100$ pounds per second.

From steam table $V = 1.49$ cu ft per lb

Area from pipe tables $= 0.796$ sq ft

Velocity, from Eq. II $= \frac{wV}{A}$

$= \frac{100\,(1.49)}{0.796}$ $\qquad v = 187$ ft per sec.

From Fig. 7, kinematic viscosity $=$ 2.75 (10^{-5}) sq ft per sec.

Then:

$$R = \frac{Dv}{y} = \frac{(1)\ (187)}{2.75\ (10^{-5})} = 6.8.\ (10^6)$$

Then, using Fig. 11 with this number and a diameter greater than 6 in., $f = 0.0133$

Then using equation IX,

$$P_1 - P_2 = f\left(\frac{L}{D}\right)\left(\frac{v^2}{2gV}\right)$$

$$= 0.0133\left(\frac{100}{1}\right)\left[\frac{(187)\ (187)}{2\ (32.2)\ (1.49)}\right]$$

$P_1 - P_2 = 485$ lb per sq ft, or 3.37 psi

Prior to the introduction of the Reynolds Number for the solution of ordinary pipeline problems, several empirical formulas for pressure drop were used. Two of these equations are given below.

The Fritzsche formula is used for air and steam.

$$p_1 - p_2 = \frac{0.82LV\ w_a 1.85}{d4.97} \qquad \text{Eq. X,}$$

Where,

$p_1 - p_2$ = pressure drop, pounds per square inch

d = internal diameter, inches

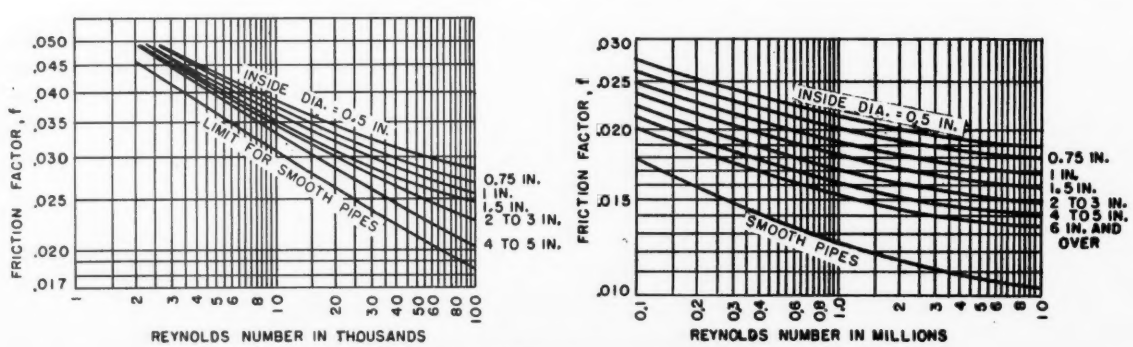
w_a = rate of flow, pounds per minute

Other symbols are the same as previously used.

The Unwin-Babcock formula has often been used for the flow of steam in clean steel pipes.

$$p_1 - p_2 = 0.000131\left(\frac{1+3.6}{d}\right)\left(\frac{LV\ w_a^2}{d^5}\right)$$

For low pressure, low temperature



Figs. 10 and 11. Friction factors for new steel pipes

steam this formula is satisfactory. However, for high pressure superheated steam results obtained by the use of this formula often show large errors. The Reynolds Number method is far superior to any empirical relation.

The methods presented in this article are a handy means by which any operating engineer can check fluid flow in his plant. Careful study will show that the combination of theory and test results gives a practical means for the betterment of power plant performance.

REFERENCES: Figures No. 5 to 11 inclusive, HEAT - POWER ENGINEERING; Barnard, Ellenwood, Hirshfeld; John Wiley & Sons, Publishers.

PRACTICAL HINTS AND KINKS

TIME AND LABOR SAVER FOR ERECTING POLES

By FINLEY M. MILLER,

Line Foreman, New England Power Service Co.

WITH A LARGE number of poles to be set across comparatively open country and realizing how long it would take us by the old method we devised the mobile unit pictured. We took the Athey wagon into the shop and made this "Athey Wagon Gin Pole" as we call it. Here is how to make one for your own crew

A piece of angle iron 4 in. x 4 in. x 10 ft is bolted to the frame on the back end of the Athey Wagon. A hinge is formed by bolting three bolt eyes to the angle iron at the middle, and by placing two oval eye bolts through the bottom of the gin pole, and running a ⅝ x 10 in. bolt through the bolt eyes and oval eye bolts. Two side guys are attached to the gin pole about 15 ft above the Athey Wagon, and are held by two coffin hoists attached to either side of the angle iron by the use of bolt eyes. (Coffin hoists are used only to move gin.) By running the winch line from the tractor through the snatch block at the top of the gin pole it can be lowered from 30 to 45 degrees and proves to be more convenient to do so when moving from structure to structure. The 35 ft spruce gin pole was guyed for setting poles in the usual manner using four ropes.

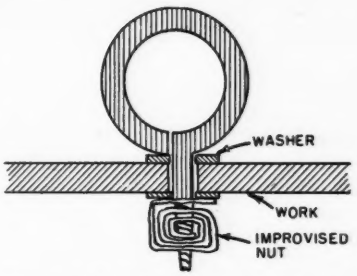
Poles ranging from 40 ft to 85 ft were set with this outfit, and "A" frames up to 55 ft were stiff heeled in. In setting poles a snatch block is used at both the top and the bottom of the gin pole, but in stiff heeling in an "A" frame it is only necessary to use one at the top.

The pictures were taken three days after the outfit was in use, when it was still just an idea.

A FASTENER FOR THIN STOCK

By William A. Sheffer, Jr.

WHEN IT becomes necessary to attach a bit of work of thin stock, either metal or wood, using a wood screw, screw eye, or such, one can simply take a strip of sheet copper or other pliable metal, bend it upon itself several times, drill a hole thru the center, slightly smaller than the body of the screw to be used, and then use as an ordinary nut. The screw will form its own threads, and the holding power of this simple fastener is amazing.



This method of fastening thin stock gives a permanent grip without injury to the stock itself

OLD TRANSFORMER TRANSFORMS VEGETABLES

A PRESSURE cooker to process and can assorted produce made from odds and ends. The finished product was made from an old discarded G-E transformer case by employees of the Toledo Edison Company.

Making this pressure cooker will save money in two ways; cost of the cooker, and food cost

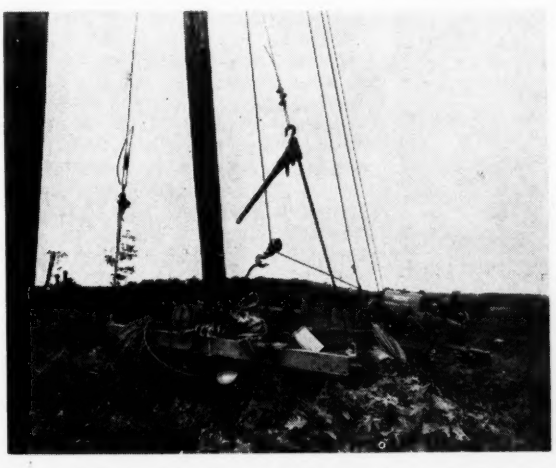


Fig. 1. Here the Athey Wagon with gin pole attached has just finished raising power pole into position. Note the track laying tractor for rough terrain

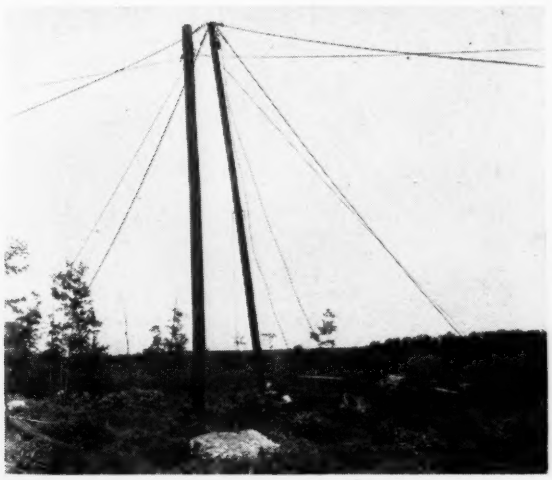


Fig. 2. This close-up shows the method of fastening the gin pole to the Athey Wagon and the manner in which it is stayed

Eliminating Fuel Waste

Here is a listing of some of the many things which a service engineer finds being done wrong . . . Many times feedwater heaters are delivering water at a temperature so low as to defeat the purpose of the equipment and all because of faulty, easily corrected installation . . . The discharge of live steam to atmosphere or hot wells is another common source of heat wastage

By H. D. ELFRETH, *Service Manager and*
A. MacHARG, *Service Engineer, Cochrane Corp., Philadelphia*

THE SERVICE engineer in his routine calls on power plants is frequently astonished at what appears to be a disregard of fuel saving possibilities in the average plant. Many operators apparently are of the opinion that such losses are to be expected and cannot be remedied. This is surprising in view of the common knowledge that approximately 1 per cent of fuel is saved for every 11 F that the temperature of the boiler feedwater is raised. It is frequently noticed that:

1. Exhaust steam is being discharged to atmosphere instead of being used in a feedwater heater to raise the boiler feed temperature.
2. High temperature condensate is being discharged into low pressure receiving tanks vented to atmosphere or into open hotwells.
3. The blowdown from boilers is being discharged directly to waste instead of through a heat reclaiming system.
4. Even in plants where feedwater heating equipment has been installed, faulty installation or operation occasionally prevents the securing of the saving for which the unit was purchased.

In a recent inspection, a Cochrane deaerating heater designed to operate at 10 psi and to heat the feedwater to 240 F was found to be delivering water to the boiler feed pumps at 100 F, this deficiency in temperature representing a fuel loss of 12 per cent. The reason was found to be that the heater had been installed at such a low elevation that there was not sufficient static head for adequate pumping without flashing. The heater is now being raised so as to secure the proper static head on the boiler feed pump suction and to permit operation at the designed 10 psi pressure. This will increase the feed water temperature to 240 F and insure satisfactory deaeration.

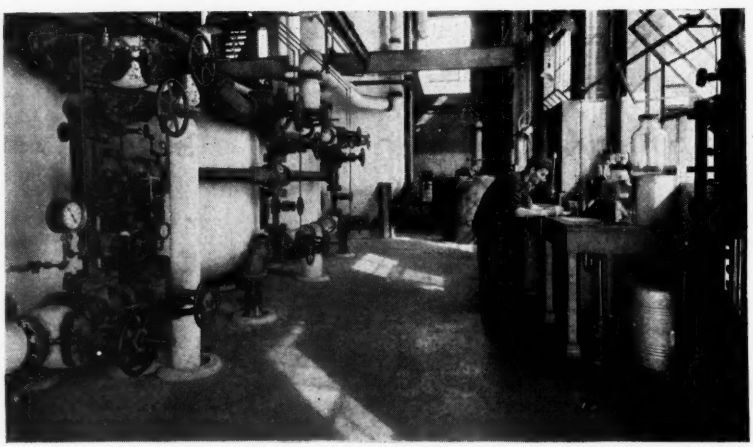


Fig. 1. Flash tank above and heat exchanger below at the Cities Service Oil Co. refinery at Petty's Island, N. J. This equipment is part of the continuous blowoff heat recovery system that reclaims heat in blowoff water at the rate of four times its cost and has done so each year for the past 10 years

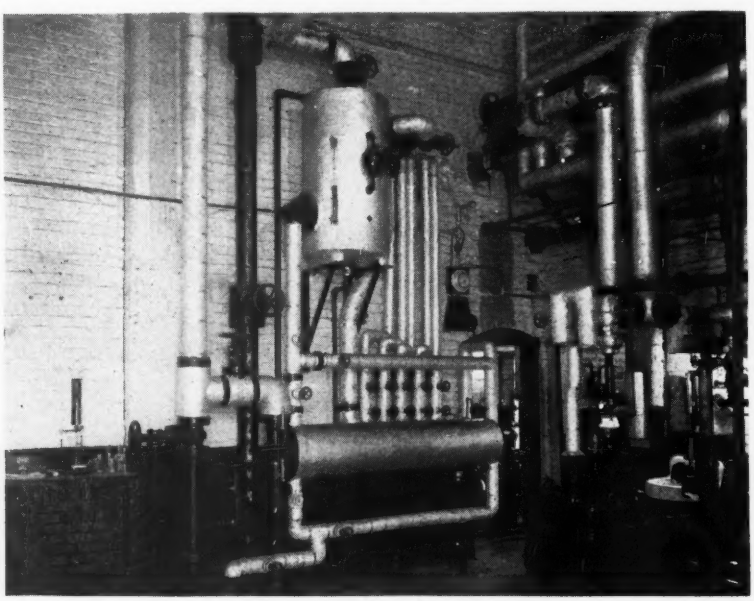


Fig. 2. At the extreme left is a Cochrane oil removal filter installed at Henry Disston & Sons, Inc., Philadelphia, for recovery of contaminated condensate. Beyond, in the background at the left, are two treated water filters and a deaerating hot process softener sedimentation tank

It is also a common occurrence to find a feedwater heater properly installed and providing adequate head on the boiler feed pump suction but delivering feedwater at a temperature so low as to entirely defeat the purpose for which the installation was made. Investigation will show that the atmospheric vent valve is shut off tight, thus preventing the elimination of the non-condensable gases which are liberated from the water in heating. These non-condensable gases accumulate in the heating section of the unit and prevent the entrance of steam into the heating section. In such a case, merely opening the vent valve a sufficient amount to show a slight flow of steam to atmosphere will immediately correct the trouble.

It is also a common experience to find traps draining live steam sepa-

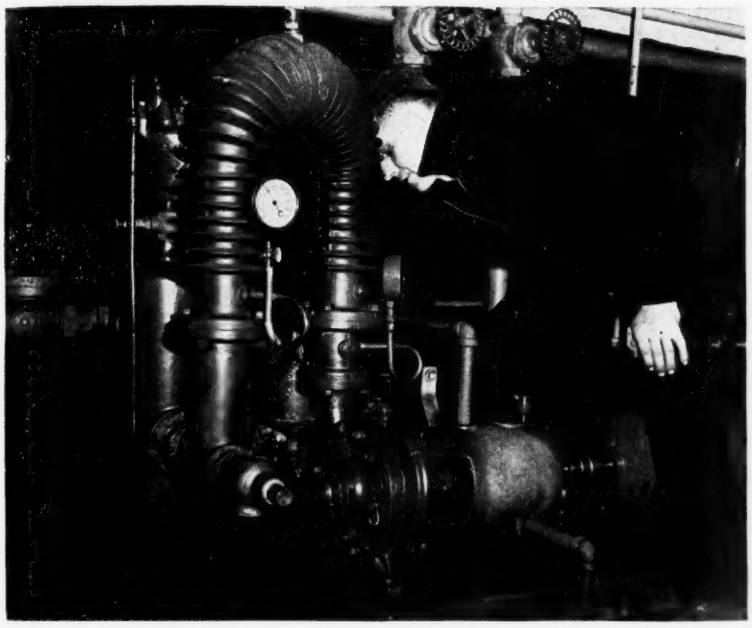


Fig. 3. This high pressure condensate return system permits the saving of 15 to 25 per cent of fuel costs by returning condensate to the boiler as it is formed without flash loss and without loss of heat which would be caused by cooling down to 212 F in an open heater

rators or steam headers discharging to waste or to atmospheric receiving tanks or hotwells. The condensate should be discharged to the connection provided on the feedwater heater, thus not only saving the water itself, but utilizing the flash steam from the high temperature condensate for heating the cold makeup water.

It is surprising to find a number of plants still blowing down their boilers directly to waste, and on some erratic schedule determined by the judgment of the operators. The use of a continuous blowdown system would not only result in the maintenance of a uniform concentration in the boiler but would also reclaim the heat in the blowdown water which is otherwise going to waste. The following suggestions will serve as a check list in determining the savings possible in any particular plant:

1. Maintain a High Feedwater Temperature. Recover exhaust steam that might otherwise be wasted by utilizing it in a direct contact open or deaerating feedwater heater. Do not allow any steam to escape to atmosphere that can possibly be used in the plant.

2. Recover the Heat in Boiler Blowoff Water. The steam flashed in flash tanks can be used in the feedwater heater or process lines. Heat exchangers recover the remaining heat in the blowoff water before discharging it to sewer.

3. Return All Condensate to the Boiler. If oil contaminated, remove the oil from the exhaust with a steam purifier or pass the condensate through an oil removal fitter. To run condensate to the sewer is sheer waste of heat and water. Enter trap discharges and heating system returns to the open feedwater heater. Avoid loss of flash steam in open receivers and hotwells. Return high temperature condensate from corrugators, dryers, process kettles, etc., directly to the boiler by the use of a condensate return system.

4. Reduce Moisture Content of Steam. Steam purifiers can reduce the moisture from 5 per cent more down to less than 1 per cent, resulting in dryer, hotter steam.

5. Check Boiler Water Treatment. Accumulations of scale on any heating surface seriously restricts the transfer of heat and such deposits are a major cause of boiler troubles

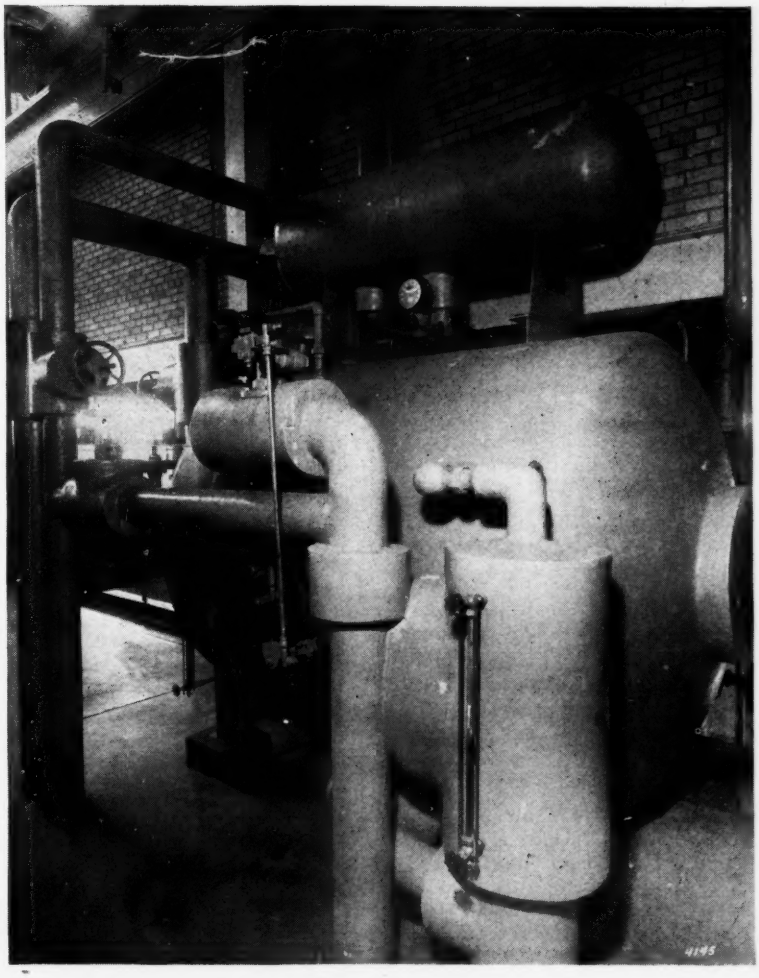


Fig. 4. Exhaust steam is used to heat and deaerate boiler feedwater in this atomizing deaerator. Note the extensive use of insulation

in addition to waste in fuel. Corrosion is both dangerous and costly.

6. Keep on the Watch for Steam and Hot Water Leaks. A ⅛ in. diameter steam leak in a 100 psi line will cause the loss of over 50,000 lb of steam in a month. Make sure that all valves in steam line close tightly.

7. Insulation or Lagging. Keep all piping and steam using equipment properly insulated to cut down heat losses.

8. Practice Preventive Maintenance. Don't wait until trouble catches up with you. Be on the lookout for it. Keep a reasonable supply of replacement parts on hand, as they are often difficult to secure when you have a breakdown. Make use of all available instruments, and regularly check the efficiency of your equipment with them. Avoid overloading boilers above their efficient operating rate. Keep furnace baffles tight and use soot blowers regularly.

With the increased cost of fuel over the past few years it becomes more important than ever to keep a continuous check on sources of waste in steam power plant operation as well as in all the other phases of business-like management.

The ABC of Laundry Equipment Heating

The author briefly reviews the principles involved in heating with steam and then launches into a discussion of basic arrangement of traps and the reasons involved

By CLOYD J. RAY

Senior Operating Engineer, Post Laundries, Ft. Riley

THE PURPOSE of this article is to closely group the principles and problems of steam laundry equipment heating that they may be easily and quickly reviewed by those who have problems from time to time in this phase of laundry operation.

A knowledge of the properties and behavior of steam is most important and perhaps a review of the principles involved will be in order at this point. Since steam used in laundries is seldom superheated, only saturated steam will be discussed. Saturated steam is steam at the temperature corresponding to the boiling point of water at the imposed pressure. Regardless of the amount of heat added to water its temperature will not increase beyond the boiling point if the pressure remains constant. The steam generated will also remain at that same temperature so long as the pressure remains constant.

Now when the heat in the steam, that is, the heat that was required to turn the boiling water into steam (latent heat of vaporization), is extracted, the steam is condensed to water; from the boiling water to steam and back to water—all without a change in temperature. This latent heat then is, practically speaking, the "usable" heat.

The amount of heat required to raise the temperature of one pound of water from 32 F to the boiling point at a given pressure is called the Heat of the Liquid. As has already been stated, the amount of heat required to change the boiling water into steam at the given pressure is called the Latent Heat of Vaporization or simply Latent Heat.

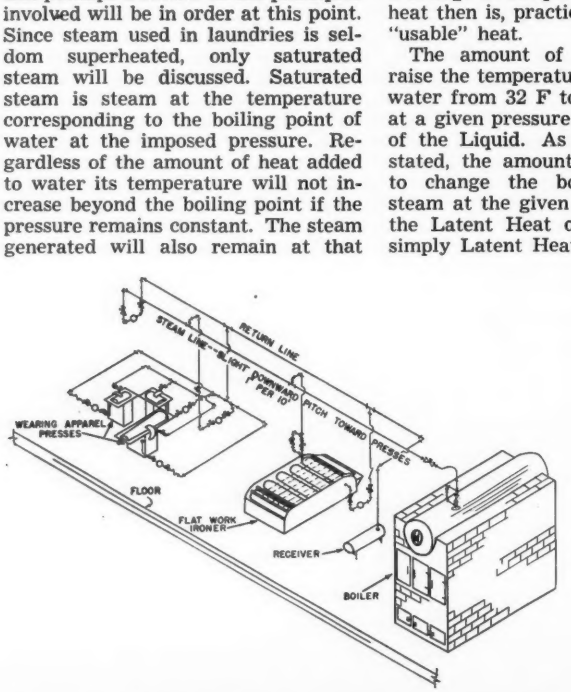


Fig. 1. Suggested laundry steam and return piping arrangement as approved by American Institute of Laundering. This is for an overhead arrangement

The sum of the Heat of the Liquid and the Latent Heat is called the Total Heat. These are properties of saturated steam. To find these values for a given steam pressure, we can refer to the tables of the Properties of Saturated Steam which may be found in most any engineering handbook.

A pressure of 100 psi is most commonly used for laundries. From the steam tables we find that steam at 100 psig (114.7 psia) has a temperature of 337.8 and the Latent Heat is 880 Btu per lb. Both gage pressures and absolute pressures are used in the steam tables. It is necessary therefore, to note which is used.

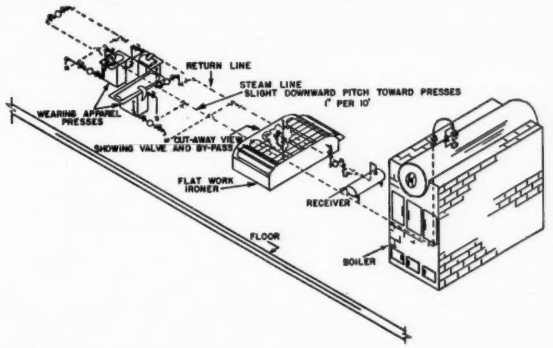
The steam is our transfer medium for carrying heat from the boiler to the equipment to be heated. The condensate that is formed when the steam gives up its latent heat to the equipment must be removed to make room for more steam since there is very little usable heat contained in the water as compared with steam. Also, any air (or other non-condensable gases) in the system must be removed because air mixed with the steam in a steam chest lowers the temperature and insulates the heating surface.

Air Removal Important

For this reason the removal of air from steam heated equipment is a very important factor. Methods of draining away condensate and eliminating air from the system vary according to the type of return system used. The most used system is called the "Open Return System" and the only system we will consider here. By "open" system it is meant the return is not carried directly to the boiler but discharges into a tank or receiver, which is vented to the atmosphere, from where it is pumped to the boiler. It is obvious that some means of eliminating air and removing condensate from the equipment without permitting the escape of steam, must be provided. The device used for this service is the steam trap.

The principles of operation of the inverted bucket trap as follows: Assume a unit empty of water and steam but filled with air. When the steam valve is turned on, steam is admitted to the equipment and begins to condense. The trap being below the unit the condensate flows to the trap. With the bucket in the down position and valve open, the condensate will flow out through the trap valve into the return line. The bucket will remain in the down position with the valve open until gases, which are lighter than water, rise to the top of the bucket displacing the water until the bucket becomes buoyant, when it rises and closes the trap valve. If the gas in the bucket is air, it will pass through the small vent hole in the top of the bucket and displace the water in the trap bc[illegible]. Without this water, the bucket drops to the bottom. In dropping it opens the valve and

Fig. 2. Another suggestion of the Institute's for an under-the-floor plan of piping



the accumulated air escapes through the valve orifice.

This action continues until the air has been eliminated. When steam enters the bucket in the down position, the water in the bucket is displaced by the steam causing the bucket to become buoyant and rise. This steam condenses a little at a time as it seeps through the vent hole in the bucket, but enough steam constantly enters the bucket to just equal the steam condensed. The trap will remain closed until the supply of steam to the trap is shut off by accumulation of condensate in the inlet line. The steam in the bucket continues to condense, the bucket loses its buoyancy and drops, opening the valve, permitting the accumulated condensate to be discharged by the steam pressure. With the discharge of this condensate the line to the trap is again clear, steam enters the trap, is caught by the bucket again causing the bucket to become buoyant and rise, closing the valve.

Having been delivered to the return line by the steam trap, the condensate flows back to the receiver. The remainder of the cycle need not be discussed here.

It has been shown that steam will always be at the same temperature for a certain pressure. In other words, pure saturated steam at 100 psig will always have a temperature of 337.8 F. If we have a pressure of 100 psi in the equipment to be heated and the temperature is lower than 337.8 F, the equipment is not filled with pure steam but is diluted with some other gas (probably air), concentrated because of improper and insufficient drainage and air elimination. It follows then, that drainage and air elimination is the chief factor involved in obtaining maximum and uniform temperatures. This in turn means proper trapping.

It is not the purpose of this article to discuss in detail all of the problems and remedies involved in heating laundry equipment. Some of the common troubles encountered, their causes, and the corrections will be discussed generally.

One of the most common troubles encountered is caused by draining more than one unit with a single trap. The traps will handle condensate and air but close against steam. When all water is drained from one of the units, the trap closes and this closing may interfere with the proper drainage of the other units and cause one or more of them to become airbound or partly filled with condensate. The proper remedy is to install a separate trap for each unit.

There are, of course, troubles due to broken valves, broken or worn trap parts, plugged openings, dirt collection in trap bodies, lines too small, trap too small for job, trap designed for pressure lower than the pressure carried, boilers priming, and other related operating troubles.

Let us consider the flat work ironer of the roll and chest type, where it is important that quick drying be obtained. It is a well known fact that quick drying improves the appearance of fabrics being ironed. Quick drying can only be obtained when the steam chest is filled with hot, dry steam and in order to obtain this proper drainage and air elimination are required. If these requirements are not met, air entrained in the chest becomes mixed with the steam resulting in a lower temperature. The steam chest of the ironer is made up of several separate compartments or chests. In order that maximum and uniform temperature be obtained, each compartment must be equipped with an individual trap. "Short circuiting," which occurs when more than one unit is drained by a single trap will thus be prevented.

When only one trap is used to drain all the units, and short circuiting does occur, steam is carried in the return header of the machine and backs up in the chests, resulting in steam being fed into them from both the supply and the return. This stagnated circulation results in poor drying, machine must be run slower, and sometimes the work must be put through the ironer the second time to produce finished work.

Manufacturers of laundry equipment recommend that steam pressures of 85 to 100 psi be used with flat work ironers. Pressures are sometimes raised to as high as 125 psi to overcome the effects of improper drainage. Raising the pressure seldom gives the desired relief or results, the proper solution being correction of the faulty drainage.

Drying tumblers are usually equipped with two or more separate coils, and in many cases, are served by a single trap. The draining of more than one coil with a single trap will result in a lower heat output than is the case where each coil is drained independently by an individual trap. Whether it be tumbler coils, dry rooms or curtain dryers, air binding will result if more than one coil is drained by a single trap. The circulation must be positive if maximum heating is to be accomplished. Tumblers should be equipped with a trap at the steam inlet to assure a supply of dry steam entering the coils. As a matter of fact, this is good practice on all the equipment.

The matter of loading the tumbler cylinder has nothing to do with the problem of keeping the heating coils at maximum temperature but it does affect the operation of the whole unit. No doubt most laundry engineers have been called upon to locate and correct the cause of slow drying in a tumbler only to find the cylinder so heavily loaded the air circulation was blocked. These units cannot operate efficiently unless properly loaded and the coils and screens kept free of lint and dust. When a tumbler cylinder is too heavily loaded the heated air merely passes around the load instead of passing through it. Overloading the cylinder places undue strain on the driving mechanism, particularly when reversing, and can lead to heavy expense for repairs.

The problems encountered in the heating of presses vary somewhat with various types but the general principles involved are the same. Here again the common fault is that of more than one press being drained by a single trap. Maximum temperatures cannot be obtained when this condition exists due to the natural tendency to short circuit. The proper method is to trap each press independently. Each press actually has two compartments, the buck or stationary side, and the movable head. For this reason, press heads will indicate a lower average temperature than an individually trapped unit. By separating the buck and the movable head and draining each of them independently with an individual trap, the maximum uniform temperature can be realized.

Another condition found with one type of press, one which seems almost too obvious to warrant discussion, is that of using the top connections on the movable head instead of those on the side, or rim of the head. The rim taps are marked "inlet" and "outlet" and there seems to be no reason for using the top taps. It is obvious the head cannot be completely drained through the top taps and poor performance will result if they are used.

The use of a good portable contact pyrometer will be found most beneficial in the laundry as a check on

equipment performance. Any doubt as to whether or not a unit is at proper temperature can be immediately satisfied and steps taken to remedy trouble should any exist.

Since the steam trap is a very important piece of equipment in the laundry it should have proper and expert care. Traps should be opened for inspection and cleaning at regular intervals. It is a good plan to blow the lines out while the trap is open for repairs or cleaning.

temperatures indicated on an eight-roll ironer while in use. The temperatures shown are the average of hourly readings for one day under each condition.

(1) Entire unit served by a single large master trap.

(2) The ¼ in. steam manifold cross-over drain removed and a separate trap used to drain the manifold.

(3) Each chest and steam manifold individually trapped.

The A B C of equipment heating may be summed up as follows: A—An adequate supply of dry steam delivered to the equipment; B—Proper and adequate drainage facilities; C—First class maintenance of the facilities.

Steam Pressure—102 psig

Chest No.	1	2	3	4	5	6	7	8	Average
(1) Deg F	310	312	310	300	290	305	308	312	309
(2) Deg F	312	312	315	315	300	310	325	325	318
(3) Deg F	332	332	332	332	332	332	332	332	332

It is important that traps be of the proper size and pressure for the job. All manufacturers of steam traps will gladly furnish the data necessary for trap selection and installation.

In the table are shown surface

Compressed Air Line Explosions

What causes compressed air lines to fail? Is it the oil? Too much, or the wrong kind? Is it that the air leaving the aftercooler is too hot? Or, is it because the relief valve or fusible plug fails to work right? What of fittings?

(Editor's Note: This subject originally came up in a question in the Q & A section. Because it is a subject of such wide application and because every compressor operator should realize the dangers, we are publishing two of the answers as a separate article.)

CAUSES AND CAUTIONS

By Charles W. Parks

EXPLOSIONS IN compressed air lines and equipment, are caused by spontaneous combustion of oil vapor in the hot discharge air. However, if such an air line did fail due to over pressure or fracture of one or more of the fittings, this fracturing could produce a spark to set off the explosive mixture in the line without spontaneous combustion taking place. Although I have no proof to support my theory, I have always contended that, static electricity, generated by belt driven compressors could cause an explosion under the right conditions.

M. A. E. states that the operating pressure was 400 psi while the safety valves were set to blow at 525 psi. This is not good practice because the safety valves seldom get a chance to blow. They should have been set for around 410 or 415. This gives them a chance to blow once in a while and keeps them active whereas, under the conditions set down by M. A. E., they would tend to stick and fail to blow at the required time.

There are several events that lead up to an explosion in air lines, and the best way to combat the evil is to rid the system of these items. The real cause of the explosion is too much oil or the wrong type of oil used in the air cylinders or a combination of both. The excess oil passes over into the air lines and when the air gets hot enough, vaporizes. If the oil has a low flash or fire point and the air gets hot enough, the explosive mixture will be ignited by spontaneous combustion unless a spark is created by friction or loose parts or else by static electric arcs. We can list the causes and preventions of air line explosions in the order of their importance somewhat as follows:

(1) Lubrication.

Air line explosions may be caused by too much oil being fed to the air cylinders or by the use of inferior or improper oils. Oils used in air compressors should be of the best grade and made especially for them. They should have a flash point of from 400°F to 450°F and a fire point of from 475°F to 525°F. The specific gravity should be from 20° to 30° Baumé and a viscosity of from 230 to 320 seconds Saybolt. The oil should be medium bodied pure mineral oil of good quality from a reputable firm and should contain no vegetable or animal oils. The correct amount of oil feed should be found (drops per minute) for the type and size compressor and no more than this amount fed.

(2) Air Discharge Temperatures.

As the tempertaure of the discharge air is one cause of explosions, it should be kept at a minimum. Some of the cause of excess air temperatures are:

(a) Loose or broken valves or parts.

(b) Inadequate supply or failure of cooling water supply.

(c) Water temperature too high.

(d) Dirty cooling surfaces.

Loose or broken valves or parts cause the air to be churned back and forth creates abnormal heating.

Inadequate supply or failure of water supply causes excessive heating because the heat of compression is not carried away only by the air itself. A good supply of cool clean water should be provided and means provided to assure an uninterrupted service or supply. Water for cylinder jackets should be cool and if it is not cool at its source, some means must be employed to cool it before it reaches the cylinder jackets. Cooling towers are a valuable aid for this purpose.

Dirty cooling surfaces prevent the proper transfer of heat. All cooling surfaces and tubes and passages should be kept clean. The passages around the valves and cylinder heads should be boiled out frequently with some sort of solvent. The water should be kept clean by means of strainers and should be free from corrosive chemicals.

Excessive air temperatures are also created by overloading the compressor. The compressor may be overloaded by running it too fast thereby producing a greater volume of air than it was designed for. Air compressors are designed for a given amount of air and any more than this causes excessive friction of the valves and also produces a lack of sufficient cooling surface because the cooling surface was designed for the designed capacity. When more air is required, it should be obtained by more air compressors and not by more speed of the original unit. This, however, is a common fault in many plants.

(3) Safety Devices and Precautions.

Proper fusible plugs should be installed in the air discharge line of each compressor. When the air temperature rises above normal, the plugs melt out, the same as in a boiler and gives a warning that there is trouble and it has to be corrected before operation can be resumed. Compressors should be overhauled

periodically to assure they are in good working order.

Some precaution should also be taken with the air intake. The intake air should be properly filtered so that dust and lint will not enter the compressor with the air. This is especially true around cotton mills, saw mills or where other combustible or explosive dusts are likely to be encountered. These dusts coat valves and passages and air lines and form a basic combustible material when explosions do occur. Abrasive dusts cut the valves and seats.

Valves and cylinders should never be cleaned with inflammable materials such as gasoline, kerosene etc. These materials will form a gas that will collect in pockets and stay there until the air gets hot enough to set them off.

Belted compressors should be properly grounded to prevent generating any static electricity. Even if this does not contribute to an air line explosion, it is very cheap insurance and should be done as a precautionary measure.

If the above procedure is followed with air compressor installations, there will be little or no trouble with air line explosions.

TOO MUCH OIL

By George G. Avant

THE EXPLOSION, in my opinion, was caused by incandescent particles of carbon coming in contact with an accumulation of oil in the compressed air system.

M. A. E. does not give enough information along with his question. From the operating pressure it is assumed that the compressed air went through several stages to reach 400 psi. Somewhere along that line the valves of the compressor were allowed to accumulate an excessive amount of carbon. This carbon comes from the lubricating oil; all oil produces some carbon. A leaking intake valve will cause a rise in temperature; this rise will cause the excess carbon to become red hot; then several small particles will fly off and travel down the line. When they come in contact with an oily surface, ignition takes place and there is an explosion.

From my experience, the valves in the compressor should be cleaned free of carbon at regular intervals. The lubricating oil should be of the best grade as recommended by the makers of the compressor. The air receivers and lines should be thoroughly drained of any moisture and oil. All receivers should have a safety plug.

I cannot understand why M. A. E. would use cast-iron fittings for 300 lb pressure, when he was operating at 400 psi and his safety valves were set for 525 psi. He should have used all steel fittings.

Questions And Answers

Q & A—The Power Engineer's Forum—Here's How It Works

YOU HAVE a question about some detail of power plant operation, maintenance, design. You can't find the answer in your own experience nor in the books. So you write in to our editors. If we know the answer, we send it right back to you. (Maybe we don't know the answer either, but we usually know where to get it for you.)

In any case, we publish your question, signed only with your initials. We do not reveal your identity. Dozens of engineers write in to give you their answers. We send you copies of the replies as soon as we get them. Then, so far as space permits, we publish those replies as soon as possible, so that everybody will learn what the others know about the problem. We pay well for all answers published.

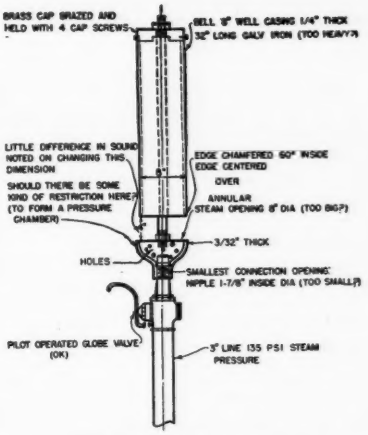
Simple, isn't it? And effective? Just ask the power engineer who has tried it!

For 10 years we have been conducting this power engineers' forum. You have endorsed it enthusiastically by your answers to questions. In short, this is YOUR section. All we do is change abbreviations to our style, shoot in a few commas with our comma gun, take a look at your spelling. But the section is really what YOU make it.—Editor.

Question No. 404

HOW CAN HE MAKE THIS WHISTLE LOUDER?

PLEASE GIVE me all available information on the design of a large steam shop whistle. I have one, as shown in the sketch, which was taken apart and rebuilt by my predecessor in this plant. Now, in spite of much adjustment and changing, it still fails to produce sufficient volume of sound.


BRASS CAP BRAZED AND HELD WITH 4 CAP SCREWS
BELL 8" WELL CASING 1/4" THICK
32" LONG GALV IRON (TOO HEAVY?)
LITTLE DIFFERENCE IN SOUND NOTED ON CHANGING THIS DIMENSION
EDGE CHAMFERED 60° INSIDE EDGE CENTERED OVER
SHOULD THERE BE SOME KIND OF RESTRICTION HERE? (TO FORM A PRESSURE CHAMBER)
ANNULAR STEAM OPENING 8" DIA (TOO BIG?)
3/32" THICK
HOLES
SMALLEST CONNECTION OPENING NIPPLE 1-7/8" INSIDE DIA (TOO SMALL?)
PILOT OPERATED GLOBE VALVE (OK)
3" LINE 135 PSI STEAM PRESSURE

Sketch of J. W. D.'s steam whistle

Please give me what you can on these questions.

Should the annular opening just under the bell be equal in area to or less than the area of the smallest connection in the stea msupply line? What is the desirable ratio of bell diameter to length of bell? What actually produces the sound? Is it due to vibration of the bell itself on the surrounding air?

Chicago, Ill. J. W. D.

Question No. 405

WHAT'S THE BEST AIRCRAFT NIGHT WARNING FOR A STACK?

CAN YOU HELP me out with a stack illumination problem? Our plant is quite close to an airport and, to warn airplane pilots off the stack at night, we have to use four 1500-watt flood lamps focused on the stack.

Now I would like to find some kind of rig—perhaps a pair of red lamps at the top of the stack—that would be more economical and at the same time include a convenient method for replacement of light bulbs.

What have other engineers done in situations of this kind?

Chicago, Ill. L. B. E.

Question No. 406

FLYWHEEL EFFECT FOR DIESEL-ELECTRIC SET

PLEASE GIVE the necessary data and a simplified method for calculating the flywheel effect required in a Diesel-electric set to operate satisfactorily in parallel with an existing Diesel-electric set or sets. The Diesel engines are four cycle, and the generated voltage is 2300 volts, 60 cycles. The sets are below 1000 hp each and are used to supply lighting and small industrial loads.

How does this calculation vary for the parallel operation of Diesel-electric sets with 230 volts, direct current?

Chicago, Ill. G. M.

The purpose of the flywheel is to reduce the fluctuation of the engine speed to a specified limit, depending

on the application of the engine. The following quantities enter in the calculation:

W = weight of flywheel in pounds.
ρ = radius of gyration in inches.
δ = factor of fluctuation = $\frac{\omega_{max} - \omega_{min}}{\omega}$

$\omega = \frac{n\pi}{30}$ radians per second.

n = rpm of engine.

E = excessive kinetic energy during one torque period in inch × pound.

Then the dimensioning of the flywheel is based upon the relation

$$\frac{W}{g} \times \rho^2 = \frac{E}{\omega^2 \delta}$$

The value δ has to be chosen according to the application of the engine and is about 1/40 for marine engines, 1/100 for direct-current generators, and varies from 1/150 to 1/300 for alternating-current generators. The excessive energy E has to be obtained from the torque diagram and is represented by the area under the largest loop above the mean torque. It depends on the number of cylinders and can be put proportional to piston area and engine stroke. Thus the formula above can be written as:

$$W\rho^2 = K \times \frac{D^2 \times s}{n^2 \times \delta}$$

with D = cylinder bore in inches and s = engine stroke in inches. Values of K for different numbers of cylinders are as follows:

	1	2	3	4	6	8
$\frac{K}{10^6}$	3.56	2.98	2.05	0.905	0.92	0.74

Naturally E and therefore K depend on the pv diagram but in general the values given are close enough for slow-speed engines (n, about 300 rpm). Radius of gyration ρ can be obtained from the flywheel layout or, if the flywheel is given, by the pendulum method.

In electrical engineering when alternators have to run parallel, the maximum allowable variation ϵ in electrical degrees is of importance. A simple relation between ϵ and δ can only be obtained by assuming a sinusoidal change of angular velocity.

With β = number of cylinders and f = frequency of generator in cycles per second, the relation is:

$$\delta = \frac{\epsilon\beta\omega}{360 \times f}$$

and with $\epsilon = \pm 3$ electrical degrees, $f = 60$ cycles per second:

$$\delta = \frac{\beta \times \omega}{7200}$$

This relation shows that slow-speed engines with a high number of pairs of poles necessitate a small factor of fluctuation, and high-speed engines with a few pairs of poles a high factor of fluctuation in order to remain within desired variation of electrical degrees. On the other hand, the higher the factor of fluctuation the smaller the moment of inertia of the flywheel. The accuracy of the relation between δ and ϵ increases with the number of cylinders and should not be applied below $\beta = 4$.

Answer No. 386

ABOUT A BUMP IN THE BOILER

THE CASE reported by CLS was I think caused by some form of expansion or contraction. It is proper to have all boilers installed in a way that they will not be cramped but be able to freely expand to take care of such stresses. This is done by properly supporting them, leaving room for possible expansion. In a HRT boiler this is often done by supporting them from hanger rods from above or securing them on fixed lugs in front with rollers under rear lugs so they can expand lengthwise freely.

I recall a case where a scotch marine boiler was re-installed on shore, being merely set down flat on some I-beams embedded in masonry and being anchored fast only at the front end. In hiring a new fireman to fire this boiler it was found desirable to tell him that if he heard a screech out of the boiler when first firing it up to not get alarmed as it was merely the rear end of the boiler moving on its supporting I-beam. It probably moved only a small fraction of an inch but it was sufficient to make a screech.

I ran into another amusing case of a bump in a boiler. The day shift had the HRT boiler off for cleaning and the mechanic had entered the boiler to install a new feed line pipe. They had put a plank in on top of the flues to lay on while they worked on the piping. After they finished they told their helper to gather up their tools and close the boiler up but they forgot to take the plank out of the boiler before heating it up. The night man, after he had fired it up, began to hear a periodic bump-bump from the boiler which alarmed him so he quickly pulled the fire and shut it down and started another boiler. It was evident that the plank was floating around on top of the water and every now and then would bump against the back head. The next day the day crew opened the boiler and discovered the plank.

Further about strange noises coming from boilers—I ran across a case where a noticeable roaring noise would come from any one of a battery of three boilers connected to the same heater and stack and the man in charge of the boilers told me it was present when there was a high wind from a certain direction it blew across the top of the stack and produced this humming noise.

Logansport, Indiana C. C. CUSTER

Answer No. 396

ELECTROLYTIC ACTION IN THIS BOILER?

ELECTROLYTIC ACTION to cause corrosion in land boilers is not a common occurrence although often more or less common at sea where the feed water they often have to use has a percentage of salt in it. There is occasioned a "battery action" generating low voltage direct current electricity which has an effect to waste away the negative element of the couple. In the scotch marine boiler it is standard practice to hang and bolt fast to the fittings inside the boiler a zinc plate made especially for that purpose. The action then taking place is that the zinc plate makes the negative pole of the battery and practically all the corrosion is centered there and results in the zinc plate wasting away. It is necessary in standard practice to change this zinc plate yearly or at the end of every voyage.

The idea held by some engineers that a boiler ought to be "grounded" to free it from electricity, I think is purely a myth. I think you will find that all boilers in use are effectively grounded through their piping connections. This high pressure static electricity sometimes encountered is an entirely different thing from low pressure direct current generated by electrolytic action. The shell of a boiler cannot accumulate static as the boiler is always grounded through its connections.

Static is sometimes generated by moving gases impinging on an insulated metallic surface or is sometimes caused by friction, as for instance the static sparks that sometimes come off a belt that is slipping on a pulley.

As an example of static, here is a case:

When the fireman in a certain plant finished stirring his fire with the poker he would hang the hook up over the boiler setting where it happened to be directly in line with the discharge of the safety valve on the boiler. Then in a few minutes the safety valve would perhaps blow off directly onto the poker and charge it with static. If you were to then go and touch the poker you would get a stiff static shock that would almost break your arm. However, if left alone, the static will be dissipated into the air. This same kind of static is generated when a truck or bus is stopped by brakes so the tires slip on the ground so as to charge the metallic frame of the bus. This is why most gasoline tank trucks have a chain dragging from their chassis onto the ground to keep the static dissipated, as the action of a static spark at some time might ignite the gasoline. In extremely cold and dry weather if you wear rubber overshoes by scuffing your feet on a rug you can gather enough static to hold your finger near

an open gas burner and ignite the gas. I once saw a strange phenomena thus: A long and heavy freight train was stopping to take water at a water tank. The engineer turned off the steam a little too soon and the train stopped a little too soon and instead of the spout being over the water tank of the tender the safety valve of the boiler was directly under the spout. While in this position for a few minutes the safety valve blew off directly into the spout of the water tank. The engineer then pulled up to get into the right position to take water. When the fireman got on top of the tender to pull down the spout to take water he received a static shock that threw him down on the coal pile.

As a remedy or rather as an experiment, we suggest that the questioner might get a zinc slab and bolt it onto the interior of his boiler, for instance, he might fasten it to a brace or the feed pipe. If after a few weeks use it is found to be wasting away this would indicate electrolytic action. The causes of corrosion are, however, numerous and it might be well to have a sample of the feed water analyzed, for the possible contamination of some sort of acid that could cause the corrosion. In one case we encountered, where the feed water was pumped from an abandoned mine, it was found that it was impregnated with a corrosive gas. A simple remedy was found to be effective—to merely let the water percolate over an open air baffle when all its entrained gas would escape to the air.

I further note that the supposed corrosion complained of is in a heating boiler, which makes it a simpler matter to obviate, if the condensate from the heating mains are returned back to the boiler as there is then only a small amount of new feedwater added to the boiler from time to time.

If the water glass on the boiler should show a reddish tint it means there is oxide of iron present which is caused by some kind of acid in the water which is attacking the iron. One way to get rid of this is to neutralize the acid tendency by introducing into the boiler some sort of alkali as a few pounds of soda ash for instance. This ought to stop the tendency to rust.

Logansport, Ind. C. C. CUSTER

Answer No. 397

COULD SPONTANEOUS IGNITION HAVE CAUSED THIS EXPLOSION?

THE QUESTION asked by M.A.E. calls to mind an explosion in an air-compressor plant while I was on watch back in 1915.

This plant was on a dam construction job in the mountains of California. It contained three Ingersoll-Rand, Imperial Type X, two stage compressors, each of 1370 cu ft per min capacity, belt driven at 170 rpm by 200 hp induction motors.

The job operated two ten-hour shifts, with a one hour meal period in the middle of each shift. On the day shift, the load was heavy enough to keep all three compressors pumping almost constantly. On the night shift, the load was very light, only one machine was required, and at times no air tools would be operated for intervals of two to three hours.

After I had been operating this plant about six months, the company changed to a different kind of compressor cylinder oil, which had very different characteristics from that used previously.

One night, about a week after changing over to the new oil, no air tools were used on the nightwatch from the time of starting up at 12:40 a m until the end of the shift at 6:00 a m. About 5 a m, I made a round of inspection of the plant and noticed that part of the rubber gasket of a flanged joint near the receiver had blown out, and that sparks were blowing out with the leaking air. I then went over to the relief valve on the compressor and opened it. A shower of red-hot carbon particles blew out with the air. I immediately closed this valve.

I then decided to start up another compressor and shut down the one in operation in order to check its condition, although it was not showing any signs of trouble.

In starting up, the large gate valve was kept closed and the small gate valve was opened. There was an elbow to keep the blast away from the operators face. (Take notice that, in cheerful disregard for safety laws and codes, there were no safety valves in the discharge from the low pressure cylinder to the first valve. Those were the days of "One hand for the company and one hand for yourself"). When the compressor was up to speed, the large valve was opened first to full opening, and then the small valve closed. Meantime there was a very disagreeable blast of air from the relief valve. The elbow was to deflect this blast away from the operators face.

After starting up the second compressor, I had just closed the relief valve when I heard the sound of an explosion outside, accompanied by a flash. The safety valve let go at the same time and kept on blowing.

Outside, I found nothing wrong except the leaking flanged joint and the safety valve, which continued blowing, although the air pressure was very low and two compressors were pumping to capacity.

As the watch was nearly over, I decided to shut down, and ask the master mechanic and the day operator for help. These two men had both had several years experience in handling air compressors on similar projects. When I explained what had happened, the day operator laughed and said, "That frequently happens when you change brands of air compressor oil."

An inspection of the plant showed that the only damage was a broken spring in the safety valve and the leaking flange joint.

As near as I can explain the situation from my own observation and inquiries, it was as follows:

The compressor oil used at first had left hard carbon deposits on the compressor valves and in the fillings and pipe joints between the compressor and the receiver. The new compressor oil had loosened up these deposits on the compressor valves, and during periods of light load, they had deposited in the discharging pipe. The new oil left a greasy residue that could be easily removed with a rag and kerosene. During the night watch in question, due to no air being used, a concentration of oil vapor had built up in the discharge header and receiver. The hard carbon particles, either from the heat of compression or spontaneously, had become red hot. Then, when I started up the second compressor, opening the relief valve had reduced the receiver pressure by several pounds. Then, when I closed the relief valve, the two compressors had sent a supply of fresh air into the receiver with enough oxygen to support combustion, while the red-hot carbon particles supplied the means of ignition. The result was an explosion.

I operated the plant 3 months in 1914, and 6 months in 1915. This was the only explosion in all this time, and I was told that it had not occurred at any other time during the six seasons it was in operation. (It was closed down every winter for 4-5 months on account of snow.)

After this explosion, I endeavored to secure all the information I could on the causes and prevention of explosions in air-compressor plants.

When it is necessary to operate a large motor driven compressor for long periods at little or no load, and the machine is operated at constant speed with an unloader to control the amount of air being pumped, the best advice I have been able to obtain is to bleed the line somewhere beyond the receiver in order to keep up a small flow of air through the compressor and receiver. (A plant operating under these conditions should have one compressor of small capacity for light load periods.) This is wasteful of power, but it will prevent building up concentration of oil vapor in the receiver and discharge header.

The other precautions to be taken apply to all compressed air systems:

1. Do not feed an excessive amount of cylinder oil.
2. Watch the valves carefully, and remove carbon deposits, if any are forming.
3. Drain receivers, and all downdrop or pockets once each month.

HOWARD T. LIVINGSTON

BURSTING AND OPERATING PRESSURES OF PIPE

D = Outside diameter in inches. t = Thickness of wall in inches. Based on Barlow's Formula $P = 2f\frac{t}{D}$ P = Pressure in pounds per square inch. f = Fiber stress in pounds per square inch

Size	External diameter	Thickness	Ultimate bursting pressure		Pressures at various factors of safety							
			Butt-weld	Lap-weld	Factor of safety = 5		Factor of safety = 6		Factor of safety = 8		Factor of safety = 10	
			Fiber stress 40,000 lbs. per sq. in.	Fiber stress 50,000 lbs. per sq. in.	Butt-weld fiber stress = 8,000 lbs. per sq. in.	Lap-weld fiber stress = 10,000 lbs. per sq. in.	Butt-weld fiber stress = 6,667 lbs. per sq. in.	Lap-weld fiber stress = 8,333 lbs. per sq. in.	Butt-weld fiber stress = 5,000 lbs. per sq. in.	Lap-weld fiber stress = 6,250 lbs. per sq. in.	Butt-weld fiber stress = 4,000 lbs. per sq. in.	Lap-weld fiber stress = 5,000 lbs. per sq. in.
Standard Pipe												
⅛	.405	.068	13432		2686		2239		1679		1343	
¼	.540	.088	13037		2607		2173		1630		1304	
⅜	.675	.091	10785		2157		1798		1348		1079	
½	.840	.109	10381		2076		1730		1298		1038	
¾	1.050	.113	8610		1722		1435		1076		861	
1	1.315	.133	8091		1618		1349		1011		809	
1¼	1.660	.140	6747	8434	1349	1687	1124	1406	843	1054	675	843
1½	1.900	.145	6105	7632	1221	1526	1018	1272	763	954	611	763
2	2.375	.154	5187	6484	1037	1297	865	1081	648	811	519	648
2½	2.875	.203	5649	7061	1130	1412	941	1177	706	883	565	706
3	3.500	.216	4937	6171	987	1234	823	1029	617	771	494	617
3½	4.000	.226		5650		1130		942		706		565
4	4.500	.237		5267		1053		878		658		527
4½	5.000	.247		4940		988		823		618		494
5	5.563	.258		4638		928		773		580		464
6	6.625	.280		4226		845		704		528		423
7	7.625	.301		3948		790		658		493		395
8	8.625	.277		3212		642		535		401		321
8	8.625	.322		3733		747		622		467		373
9	9.625	.342		3553		711		592		444		355
10	10.750	.279		2595		519		433		324		260
10	10.750	.307		2856		571		476		357		286
10	10.750	.365		3395		679		566		424		340
11	11.750	.375		3191		638		532		399		319
12	12.750	.330		2588		518		431		324		259
12	12.750	.375		2941		588		490		368		294
14 O.D.	14.000	.375		2679		536		446		335		268
15 O.D.	15.000	.375		2500		500		417		313		250
16 O.D.	16.000	.375		2344		469		391		293		234
17 O.D.	17.000	.393		2312		462		385		289		231
18 O.D.	18.000	.409		2272		454		379		284		227
20 O.D.	20.000	.409		2045		409		341		256		205
Extra Strong Pipe												
⅛	.405	.095	18765		3753		3128		2346		1877	
¼	.540	.119	17630		3526		2938		2204		1763	
⅜	.675	.126	14933		2987		2489		1867		1493	
½	.840	.147	14000		2800		2333		1750		1400	
¾	1.050	.154	11733		2347		1956		1467		1173	
1	1.315	.179	10890		2178		1815		1361		1089	
1¼	1.660	.191	9205	11506	1841	2301	1534	1918	1151	1438	920	1151
1½	1.900	.200	8421	10526	1684	2105	1404	1754	1053	1316	842	1053
2	2.375	.218	7343	9179	1469	1836	1224	1530	918	1147	734	918
2½	2.875	.276	7680	9600	1536	1920	1280	1600	960	1200	768	960
3	3.500	.300	6857	8571	1371	1714	1143	1429	857	1071	686	857
3½	4.000	.318		7950		1590		1325		994		795
4	4.500	.337		7489		1498		1248		936		749
4½	5.000	.355		7100		1420		1183		888		710
5	5.563	.375		6741		1348		1124		843		674
6	6.625	.432		6521		1304		1087		815		652
7	7.625	.500		6557		1311		1093		820		656
8	8.625	.500		5797		1159		966		725		580
9	9.625	.500		5195		1039		866		649		519
10	10.750	.500		4651		930		775		581		465
11	11.750	.500		4255		851		709		532		426
12	12.750	.500		3922		784		654		490		392
Double Extra Strong Pipe												
½	.840	.294	28000		5600		4667		3500		2800	
¾	1.050	.308	23467		4693		3911		2933		2347	
1	1.315	.358	21779		4356		3630		2722		2178	
1¼	1.660	.382	18410		3682		3068		2301		1841	
1½	1.900	.400	16842	21053	3368	4211	2807	3509	2105	2632	1684	2105
2	2.375	.436	14686	18358	2937	3672	2448	3060	1836	2295	1469	1836
2½	2.875	.552	15360	19200	3072	3840	2560	3200	1920	2400	1536	1920
3	3.500	.600		17143		3429		2857		2143		1714
3½	4.000	.636		15900		3180		2650		1988		1590
4	4.500	.674		14978		2996		2496		1872		1498
4½	5.000	.710		14200		2840		2367		1775		1420
5	5.563	.750		13482		2696		2247		1685		1348
6	6.625	.864		13042		2608		2174		1630		1304
7	7.625	.875		11475		2295		1913		1434		1148
8	8.625	.875		10145		2029		1691		1268		1014

Courtesy Industrial Training Institute

ATOMICS

A New Section added to POWER GENERATION to cover current and forthcoming developments in atomic energy and related developments and applications in Nuclear Physics

Recent Developments in High Energy Physics

A brief account of some of the more important developments in the field of high energy nuclear physics. Principles involved in various types of accelerating devices. The history of the cyclotron; its limitations due to mass effect. Principle of phase stability. The frequency modulated cyclotron. The betatron and factors in its operation which led to the development of the synchrotron. Recent interest in linear accelerators. New phenomena disclosed by the operation of the 184 in. synchrocyclotron of the University of California. Possibility of billion volt accelerators

By ANDREW W. KRAMER, *Editor, Power Generation*

ONE OF THE MOST astonishing things about recent developments in atomic physics, is the speed at which new methods and discoveries are being made and the high energy levels involved in these developments. For example, in a new electron accelerator only 3 ft long developed at Stanford University, electrons are accelerated to 99 per cent of the velocity of light with a consequent energy of 1.5 mev (million electron volts). Actually, this accelerator is a wave guide, 3 ft long and perhaps 4 in. in diameter lined with gold plated disks. Yet, this small device produces 1.5 million electron volts!

This development is typical of what is happening in all branches of the field. Socially, we have made no progress in the control of atomic energy, as a matter of fact, we seem to have lost ground because the enthusiasm on the part of the people that was present immediately after Hiroshima has died down, and today the public is apathetic over the question of atomic energy. This apathy, however, does not characterize scientific thinking. In laboratories, all over the world, scientists are actively at work on multitudes of different problems, and scarcely a day passes when some new fact is not disclosed.

Only a few years ago, perhaps ten years, the accelerating equipment available was limited to a few million volts. The Van de Graff generator, Lawrence's early cyclotron, and several other devices worked in the range from one to 3 or 4 or 5 million volts. This was high compared to the few hundred thousand volts we had attained before but nothing in comparison to the hundred or more million volts of present day equipment.

The principal problem in nuclear research is the acceleration of particles — atomic bullets — to velocities which enable them to penetrate the nucleus of the atom. With the use of "charged" particles — electrons, protons, alpha particles, this means the use of high electric potentials, for it is in high potential electrostatic fields that such charged particles undergo acceleration.

The technique of developing high potentials first became necessary in

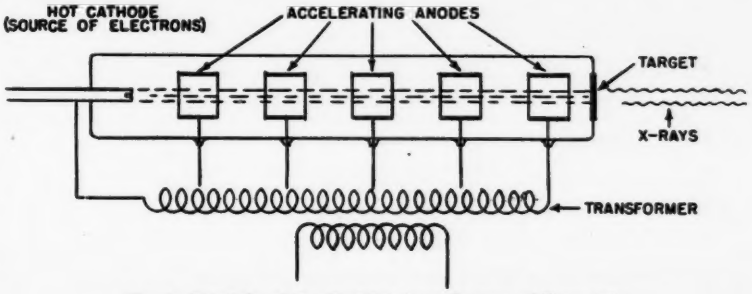


Fig. 1. Principle of the Coolidge cascade type of X-ray tube

connection with the design of X-ray tubes. As is well known, X-rays are produced by the impact of high velocity electrons on a target. Since the frequency and penetrating power of X-rays are proportioned to the voltage across the tube, ever increasing voltages were used.

Finally, however, a point was reached where the voltages could no longer be increased—the insulation of the tube being the limiting factor. To overcome this limitation Dr. W. D. Coolidge in the General Electric Co. Research Laboratory, resorted to "cascading" in which high voltages are applied in a number of stages. At each stage, the voltage is low enough to be within the insulation limits, but the effect is additive, and after passing through the several stages, the electrons have the same energy as if the total number of volts had been applied at once. The principle is illustrated in Fig. 1. Dr. Coolidge used this method about 1928.

Protons, also can be accelerated by the use of this principle and at the present time there is considerable development in this type of "linear accelerator."

Of course the early experiments in nuclear bombardment were carried on with particles that were produced, naturally, in the disintegration of radioactive elements. In Rutherford's original experiment[1] in 1919 in the transmutation of nitrogen into oxygen, he used a deposit of radium as a source of alpha particles. It was not until 1932, in the Cavendish Laboratory at Cambridge University that Cockroft and Walton achieved transmutation with particles that were accelerated artificially, that is, electrically. With potentials of some 700,000 v, in an accelerating tube, they produced the first transmutations as a result of human efforts.

Lithium was the first element to be studied in this way, and the apparatus used in the Cockroft-Walton experiment is shown in Fig. 2. A beam of protons is produced in the so-called proton gun, comprising the left-hand part of the tube. It consists of a heated cathode C emitting electrons. These are accelerated by the positive potential applied to the anode A. Passing through the aperture in A they ionize hydrogen atoms in the space beyond and these positive ions are accelerated by the cathodes B, these being at a potential 150,000 v negative with respect to A. This high negative potential also repels electrons back to A. The fast-moving protons, however, pass through the apertures in the two cathodes B-B and form a proton beam which then is directed at the lithium target at the end of the tube.

[1]See "Eee Equals Em See Squared" by A. W. Kramer, POWER PLANT ENGINEERING, February, 1947, p. 81.

ELECTRON AND ION ACCELERATORS

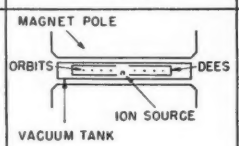
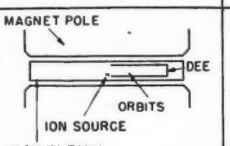
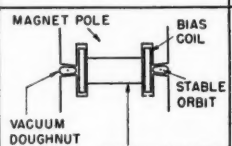
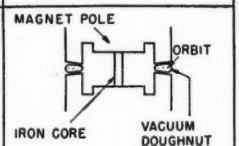
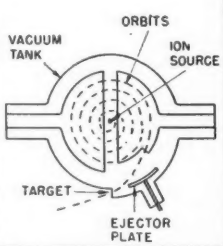
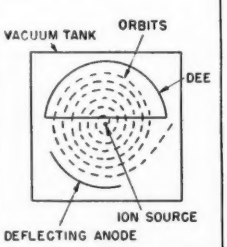
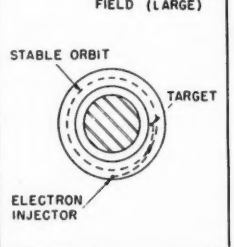
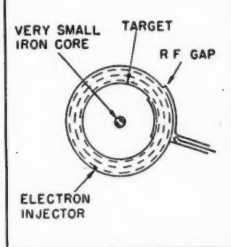
COMPONENT PARTS	CYCLOTRON	SYNCHRO-CYCLOTRON	BETATRON	SYNCHROTRON
CROSS SECTION				
LONGITUDINAL SECTION				
TYPE OF PARTICLES ACCELERATED	PROTONS, DEUTERONS, ALPHA PARTICLES, ETC	PROTONS, DEUTERONS, ALPHA PARTICLES, ETC	ELECTRONS	ELECTRONS
MAGNET	D C (CAUSES IONS TO MOVE IN CIRCULAR PATHS)	D C (CAUSES IONS TO MOVE IN CIRCULAR PATHS)	A C (CHANGE IN CENTRAL FLUX ACCELERATES ELECTRONS)	A C (PRINCIPALLY FOR GUIDING FIELD)
CAPACITOR BANK	NONE	NONE	TO BRING MAGNET TO RESONANCE AT PROPER FREQ	TO BRING MAGNET TO RESONANCE AT PROPER FREQ
VACUUM SYSTEM	LARGE TANK AND DEE STEMS EVACUATED	TANK (NO DEE STEMS TO BE EVACUATED)	DOUGHNUT-SHAPED GLASS TUBE	DOUGHNUT-SHAPED GLASS TUBE
SOURCE	ARC	ARC	ELECTRONS FROM HOT FILAMENT	ELECTRONS FROM HOT FILAMENT
ACCELERATING ELECTRODES	TWO DEES HIGH POTENTIAL	ONE DEE LOW POTENTIAL	NONE	RESONANT CAVITY OR DEES
OSCILLATOR (R F)	LARGE R F POWER AT FIXED FREQUENCY	SMALL R F POWER FREQUENCY MODULATED	NONE	SMALL R F POWER AT FIXED FREQUENCY
DEFLECTING ELECTRODES	HIGH D C POTENTIAL	HIGH D C POTENTIAL	ORBIT SHIFT COILS	NONE
APPLICATIONS	NUCLEAR RESEARCH THERAPY TRACER PRODUCTION	NUCLEAR RESEARCH THERAPY TRACER PRODUCTION	NUCLEAR RESEARCH THERAPY RADIOGRAPHY	NUCLEAR RESEARCH THERAPY RADIOGRAPHY

Chart by special permission, General Electric Review

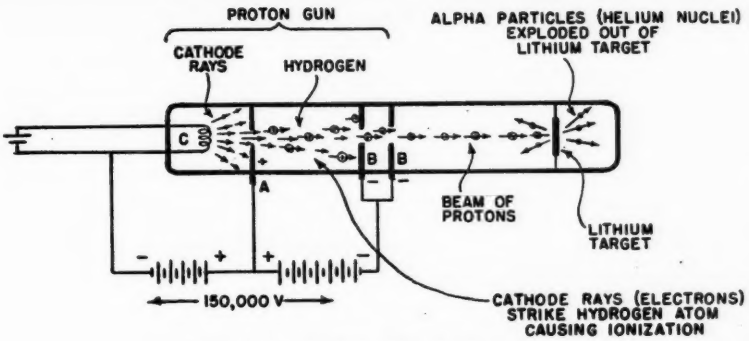


Fig. 2. The Cockcroft-Walton experiment

Here, the protons, knock alpha particles (helium nuclei) out of the lithium atoms. As explained in previous articles in this section, the nuclear reaction is as follows:

$$_1H^1 + {}_3Li^7 \rightarrow {}_2He^4 + {}_2He^4$$

In other words, by bombarding a lithium nucleus with a proton, the resulting nucleus explodes, breaking into exactly two equal parts—into two helium nuclei. This experiment was the first known instance in which an atom was actually split.

The energy relations involved in this transmutation have been described in a previous article.[2] Here, we are interested largely in the apparatus used, for this was the first time that "atomic bullets" had ever been accelerated electrically, and the Cockroft-Walton equipment pointed the way to our modern methods.

Naturally, since the energy of the bombarding particles is a direct function of the accelerating voltage, the quest was for higher and higher voltages. Since there were limits to the values of voltages which could be applied directly, the investigators turned to methods which would provide the equivalent of the voltages required, without actually having them. Among the first methods to be developed in this direction was that used by David H. Sloan and E. O. Lawrence of the University of California. The Sloan-Lawrence linear accelerator is shown in Fig. 3. It consists of a series of cylindrical electrodes along the axis of an evacuated tube. The auxiliary tube, at the left, is merely a device for producing positive ions by cathode-ray bombardment as in the Cockroft-Walton experiment. Once produced in the auxiliary tube, these ions are started along the axis of the horizontal tube by the negative potential applied to the first two cathodes. Up to this point, the process is almost exactly as it is in the Cockroft-Walton apparatus but from here on, the action is quite different. As indicated, alternate cylinders are connected together and each group is connected to the respective poles of a high frequency oscillating circuit. Thus the two groups of cylinders are given successive positive and negative charges. The action, then, is quite obvious; when the first cylinder is negatively charged, it attracts the positively charged ion, and this travels along the axis of the cylinder. By the time it reaches the space between the first and second cylinders, the polarity of the cylinders will have changed. Thus, the cylinder the ion is leaving will have become positively charged and the one it is entering will be negative. The former, therefore, repels the ion while the latter attracts it. This is repeated at the next gap between cylinders.

It should be obvious, that by this action, the ion receives a push or pull each time it crosses a gap between cylinders and, therefore, its speed increases. To allow for the continual increase in speed (since the oscillating frequency is constant) each cylinder is made a little longer than the one preceding it.

With an arrangement such as this, there is almost no limit to the energy that can be imparted to the ion, provided the system is made long enough. The dimensions of the equipment, therefore, impose a limit to the energy that can be imparted and so Dr. Lawrence thought of a better way of doing the job. He decided to twist the accelerator around into a spiral, making the ion travel successively between the same pair of electrodes. This idea was incorporated in Dr. Lawrence's development of the Cyclotron for which he was awarded the Nobel prize for physics in 1940.

[2]Ibid.

The cyclotron scarcely needs description in these pages but for those not familiar with it, a brief description will be of interest. In its original form the cyclotron consisted of two electrodes, called "dees" since they where shaped like the letter "D." The principle is shown in Fig. 3. These dees are flat, hollow semicircular boxes, like the two halves of a pill box cut in two, diametrically. These boxes are placed in an evacuated glass chamber, and the whole unit then placed between the poles of a very powerful electromagnet, operated on direct current. As in the linear accelerator, the electrodes, that is, the "dees," are connected to the poles of a high-frequency electrical oscillator.

The positive ions are produced on the center of the space between the dees, by the action of an electron beam on the small amount of gas remaining in chamber. As an ion forms, it is attracted to one of the dees, the one that happens to have a negative charge. Since the whole electrode assembly is mounted in a powerful transverse magnetic field, the ion, instead of traveling a straight path, is constrained to move in a circular path. Thus, after a half revolution within the dee, it emerges into the gap between the two dees just at the moment the polarity of the dees reverses. So, the ion is attracted to the other dee, which now is negative, and again moves in a circular path within the second dee. Since it has been given an additional push as it crossed the gap, the circular path it takes is a little larger than in the first case.

So the process is repeated many times. With each half revolution, the speed of the ion increases and hence

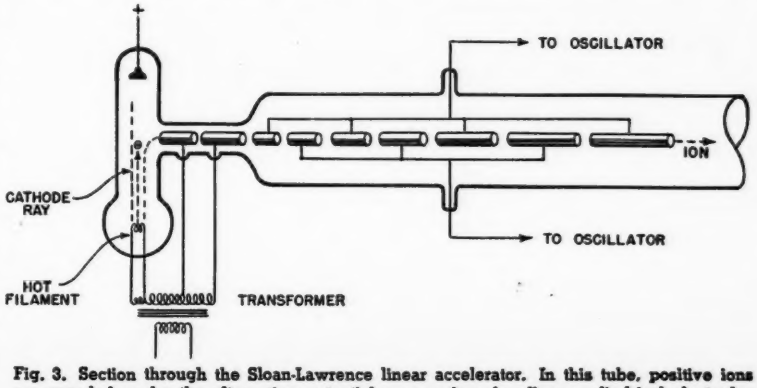


Fig. 3. Section through the Sloan-Lawrence linear accelerator. In this tube, positive ions are speeded up by the alternating potential on a series of co-linear cylindrical electrodes

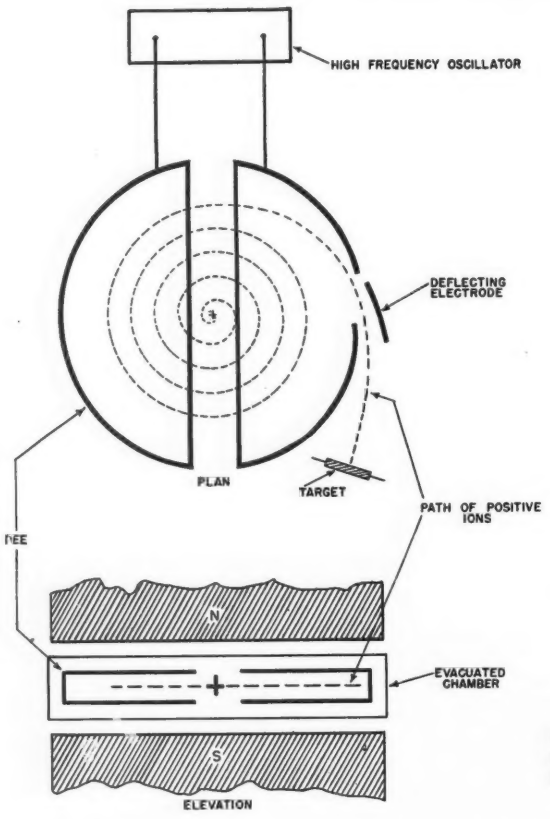


Fig. 4. Diagram showing the principle of the cyclotron

the arc it makes is larger. The path it makes, therefore, is spiral. The increase in speed with each revolution, exactly compensates for the increased length of the path with each revolution, therefore, it always takes the same time for the ion to return to the open space between the electrodes. (This is true, only when the energies remain below around one hundred million volts. When this energy is exceeded, the increase in mass of the ion as a consequence of its speed, slows down the ion). After a large number of revolutions, the ion finally reaches the outer edge of the dees, and then a deflecting electrode directs it against a target as shown in Fig. 4.

Thus, in the cyclotron, instead of subjecting the ion to a steady accelerating potential of a million or ten million volts, it is given 10 or 100, one hundred thousand volt pushes. The cyclotron develops its high voltage kick in much the same way that a man builds up speed in a heavy wheel by giving it a push each time it comes around. No single push is very hard but after a number of pushes, it attains a great deal of energy.

In the cyclotron the pushes are delivered at an extremely fast rate. The electric oscillator changes the polarity of the dees some ten million times per second. Suppose the ion is given a 200,000 v push each time. Thus in 100 revolutions, that is in 1/100,000 of a second, the ion will have attained an energy of 100 × 200,000 or 20,000,000 volts!

The amount of energy involved in the operation of the cyclotron is very great. In the case of the great 184 in. cyclotron at the University of California's Radiation Laboratory, energies of 200,000,000 electron volts are produced with only 15,000 v at the dee. Originally, it had been estimated that 2,000,000 v would be required. The reason for this great difference is due to a later development —one brought about by the effect of increase in mass of the ion at extremely high speeds.

As already indicated, at energies of over one hundred million volts, the increase in mass of the ion tends to slow down its speed. This brings it out of step with the oscillating electric field between the dees.

The actual construction of the 184 inch cyclotron (the pole pieces are 184 in. in diameter) was interrupted by the war. Of course, as pointed out by Dr. Lawrence in his Silliman lecture[3] recently, from the standpoint of getting on with the job of exploring farther into the realm of the atom, the war interruption might have been a serious loss—a delay of some five years. Actually, this delay turned out to be a blessing in disguise, for the wide experience gained in the war effort by the scientists and engineers concerned, as well as many new technological developments, contributed greatly to a more rapid and successful carrying out of the undertaking.

As already pointed out, one of the limiting factors in the operation of the cyclotron at extremely high energies was the slowing up of the ions due to the mass effect. In 1945, however, Dr. Lawrence's colleague, Dr. Edwin McMillan[4] and independently V. Veksler[5] in Russia elucidated the principle of phase stability in the multiple acceleration of particles, embodied in the "synchrotron." They pointed out with such clarity, and so convincingly, the way to higher energies that immediately after the war, when the 184-in. program was resumed, the great instrument was redesigned, following their ideas, as a synchro-cyclotron, thereby more than doubling the power of this accelerator.

New Cyclotron has Only One Dee

The novel feature of this altered cyclotron is that it has only one dee in the vacuum chamber which is kept at ground potential.[6] The oscillator is connected to this single dee, and depending upon whether it is positive or negative, the positive ions are drawn into it or ejected from it. The magnetic field, of course, keeps them in their circular paths. With the original technique, ions were introduced, speeded and ejected in a continuous stream but in the "synchro-cyclotron" or "frequency modulated cyclotron" they come in pulses at 1000 per second. When the ions start, the oscillator is operating at

[3]Silliman Lecture, Strathcona Hall, Yale University, October 15, 1947.

[4]E. M. McMillan, Phys. Rev., Vol. 68, pp 143-145 (1945).

[5]V. Veksler, Jour. of Phys. of U.S.S.R., Vol. 9, pp 153-158 (1945).

[6]James Stokley, Atomic Artillery. General Electric Review, June, 1947, pp 9-19.

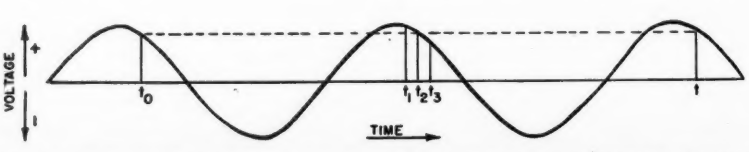


Fig. 5. In the synchro-cyclotron as well as in the synchrotron, the principle of phase stability keeps the particles in step with the alternating voltage. The voltage varies according to the time at which the particles arrive at the edge of the dee

11.4 megacycles, that is, the polarity changes 11,400,000 times per second. In the oscillator circuit, there is a motor-driven rotary condenser, and, as the ions begin to lag, as a consequence of their increase in mass, the frequency of the oscillations is smoothly reduced to 10 megacycles. Thus, they still reach the edge of the dee at the proper instant, that is, in step with the frequency.

Because of the principle of phase stability, it is not difficult to synchronize the motion of the ions with the changes in frequency. They actually tend to keep in step with the oscillations. This is shown by the curve in Fig. 5 which represents the variation in voltage at the edge of the dee. Normally, an ion would reach this position a little past the peak of the oscillation, at t_0. After a complete circuit it would come back again at t_2, receiving an additional increment of energy of the same amount.

If, however, for any reason it loses energy, or fails to get around, it will move in a smaller orbit, returning to the edge, at t_1 thus getting more than its normal quota of energy. This then brings it back the next time at t. On the other hand, if it should in some way get too much energy, the orbit will be larger; it will come back late, at t_3, receive less of an impulse, and so come back into step. Actually, of course, the ions oscillate back and forth around a mean path. Also, each time around, they receive two additions of energy, once, a push as they leave the dee, and second, a pull as they return to it.

The cyclotron, whether frequency modulated or not is used to accelerate *positive* ions. Theoretically, the cyclotron could also accelerate negative particles, that is, electrons, but it is not practicable to do so. For this purpose, the "betatron" was developed.

The Betatron

The betatron was invented and developed by Dr. Donald Kerst of the University of Illinois. His original betatron was small enough to place on an ordinary desk, yet, it produced 2,300,000 electron-volt energies.

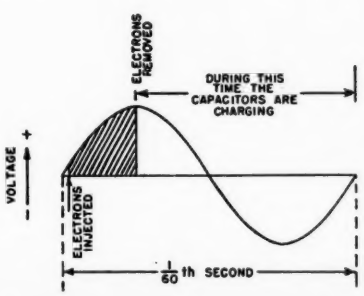


Fig. 7. In the normal operation of the betatron the particles are accelerated during the first quarter of each cycle. Then they are removed

At the General Electric Research Laboratory, which Dr. Kerst joined in 1940, he supervised the construction of a 20,000,000 electron volt unit. Later, under G. E.'s Dr. Ernest Charlton's direction a 100,000,000 v betatron[7] was constructed.

The principle which governs the acceleration of the electrons in the betatron is exactly the same as that which operates in an ordinary transformer. In the transformer, the incoming current flows through a coil of wire, the primary, and by induction, a current is caused to flow in another coil called the secondary. This current consists of a movement of electrons from one copper atom to the next.

The difference between the transformer and the betatron is that in the latter, the secondary coil is replaced by a doughnut-shaped vacuum tube. Electrons start from the hot filament in an electron gun, injected at the beginning of an a-c cycle. During the first quarter of a cycle, as the voltage builds up, the electrons are accelerated through many revolutions. If left in the tube, they would be slowed down to zero in the next quarter of the cycle as the voltage decreased and then, as it reversed, they would start in the opposite direction. In the operation of the betatron, however, they are not left in the tube after the first quarter of the cycle. At the peak of the voltage wave, that is, at the end of the first quarter of the cycle, a pulse through an auxiliary coil of wire shifts the orbit of the whirling electron, enough to bring them into collision with a tungsten-wire target which they previously missed. This impact of these exceedingly fast moving electrons generates a beam of high energy X-rays which emerges from the tube.

Figure 7 shows the action of the betatron in terms of the voltage wave. In the actual equipment, the current in the primary coil, is derived not directly from the 60 cycle power supply, but from a large bank of capacitors. These capacitors are charged during the remaining three-quarters of the cycle. Thus, the effect is the same as that obtained in a large swinging pendulum, kept in motion with a relatively small push given each swing at the right moment.

As described in a previous article[8] Dr. Westendorp of the General Electric Co. devised a method whereby the electrons in the betatron can be accelerated through almost a half cycle instead of a quarter of a cycle. This involves biasing the tube by the application of a d-c potential through

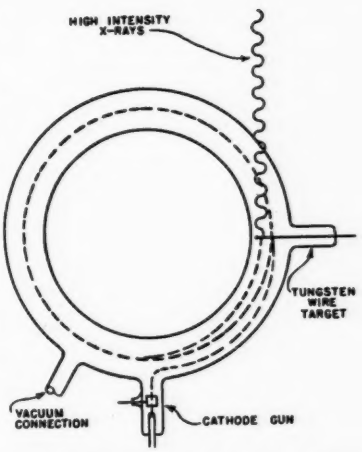


Fig. 6. Showing the principle of the betatron

special coils. By this method a betatron which ordinarily would have given energies of 100,000,000 electron volts, would give 165,000,000 electron volts with no increase in size.

The same limitations which govern the operation of the cyclotron, as regards the increase of mass of the moving particles, also applies to the betatron. In the betatron, the electrons, being far less massive than the positive ions, reach velocities approaching the speed of light much sooner than in the case of the cyclotron. Even below a million volts the electron moves at 90 per cent of the velocity of light. At 100,000,000 volts they travel at well over 99 per cent of the speed of light. At this speed the electron has some 197 per cent its rest mass. As electrons are accelerated with higher energies they actually radiate away their energy as electromagnetic waves, indeed, some of these waves are short enough to manifest themselves as visible light and in the Research Laboratory of the General Electric Co., these visible electron radiations have actually been photographed. Up to 100,000,000 v, this radiation effect is not serious but at higher energies it becomes so great that the energy is dissipated as fast as it is acquired, imposing a limit upon the ordinary betatron.

Use of Phase Stability in Betatron

As in the case of the cyclotron, this limitation can be overcome by the principle of phase stability. The machine which operates on this principle, using electrons, is the synchrotron, developed independently by Mc-

[7] Power Plant Engineering, April, 1946, p 61.

[8] Betatron Energy Raised to 160 Million Volts, Power Plant Engineering, November, 1946, p 82.

ATOMICS

Millan in California and by V. Veksler in Russia as already mentioned.

The tube in the synchrotron is like the doughnut of the betatron except that it contains a small section of glass, silver coated on the inside. This silvered conducting section contains a gap, serving the same purpose as the gap between the dees of the cyclotron. As the electrons pass this point they are given additional energy.

In the synchrotron[9] electrons are injected at the start of the a-c cycle and accelerated to about 2,000,000 electron volts exactly as in the betatron. By this time their speed is practically constant since they are moving at about 97 per cent the velocity of light. At this stage a 163.8 megacycle oscillator is connected to a silvered section in the betatron doughnut. This frequency corresponds to the time it takes the whirling electron to make one circuit in the doughnut. The oscillator causes the electrical charges on the two parts of the silver coating to surge back and forth alternately charging the charge on the two sides of the gap.

In the betatron stage, the electrons are distributed continuously around the tube but when the synchrotron operation starts, the electrons bunch together and reach the gap when the opposite side has a positive charge and they are pulled across.

Figure 8 shows the principle of phase stability as applied in the synchrotron. Path 1 in the upper left hand circle represents the normal orbit with the electron returning to its starting point. If an electron receives too little energy, the magnetic field squeezes it into a smaller orbit and it then follows Path 2. However, moving in a smaller orbit, it returns to the accelerating gap sooner and as shown in the wave diagram below in Fig. 8, it receives more than its normal quota of energy. The next time around, therefore, it tends to come back to its proper starting point as shown by Path 2 in the right hand circle. In the same way, Path 3 shows what happens when the electron receives more than its share than it should. The next time around it gets less than its normal increment and returns to normal.

This, then, is the principle of the synchrotron, a powerful and extremely compact accelerator which provides great promise of becoming an exceedingly useful tool in nuclear research.

Strangely enough, now that the cyclotron, the synchro-cyclotron, the betatron and the synchrotron have been developed and brought to a high degree of perfection, renewed interest is being accorded the linear type of accelerator exemplified by the Sloan-Lawrence linear accelerator described at the beginning of this article. The reason for this renewed interest is that at the time work on the linear accelerator was abandoned in the early thirties there were no sources of high frequency impulses of sufficient high energy available. With the wartime development of radar technique we have at our disposal high frequency pulse sources of exceedingly high power.

New Linear Accelerator at the University of California

It was Dr. Luis Alvarez at the Radiation Laboratory of MIT who got the idea, that these radar pulse transmitters were exactly what was needed. As a result, back at the University of California, he began work on a linear accelerator using these radar transmitters. Dr. Alvarez' accelerator will accelerate protons and while his plans call for an initial maximum energy of 40,000,000 electron volts, ultimately his project will be extended to produce 280,000,000 electron volt particles.

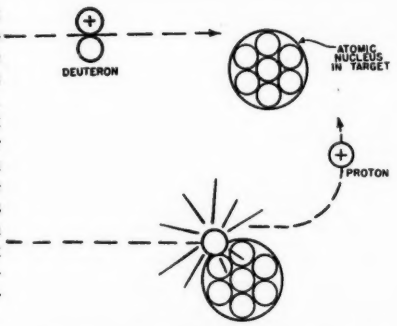


Fig. 10. This is what happens when the neutron of the deuteron just hits the nucleus. In this case, the proton continues its flight but is deflected by the magnetic field of the cyclotron

Eventually, he hopes to go to a billion volts.

His present machine will be about 40 ft long and will use 30 radar sets, to develop 40 million electron volts.

It will be some time before these more powerful linear accelerators will be developed. In the meantime, the circular accelerators, the synchro-cyclotron and the synchrotron will provide ample energies for immediate needs. Already the 184 in. frequency modulated cyclotron has shown remarkable powers. As pointed out by Dr. Lawrence in his Silliman lecture, the 184 in. synchro-cyclotron was turned on for the first time on November 1, 1946, and since that time has been producing deuterons of energies up to 200,000,000 electron volts and alpha particles up to 400,000,000 electron volts.

When the 184 in. instrument was first turned on—indeed, during the first evening of operation—a sharply defined beam of penetrating radiation was observed coming from the probe target in the cyclotron chamber. This extraordinary interesting phenomenon was immediately the subject of some preliminary exploratory experiments. Measurement of the penetrating power of the beam showed that it required a foot of lead or concrete to reduce its power to one half. This indeed was some-

[9]James Stokley, "Atomic Artillery," General Electric Review, June, 1947, pp 9-19.

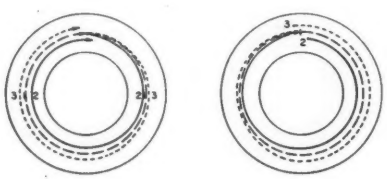
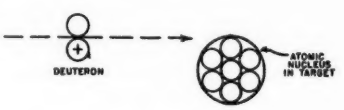


Fig. 8. (Left) Phase stability as applied in the operation of the synchrotron. As the electrons are accelerated their orbits are modified to conform to the amounts of energy they receive



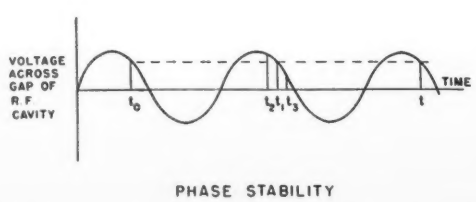
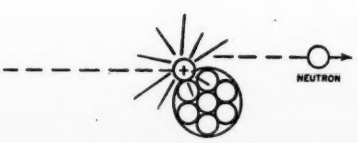


Fig. 9. (Right) Nuclear reaction involved in the operation of the 200 Mev neutron beam with the 184 in. synchro-cyclotron. Atomic nucleus is bombarded with deuterons



thing new in the laboratory. It was soon proved that lead was not as effective a shield for this radiation as water or concrete. This indicated that the beam was made up largely of neutrons. The average energy of these neutrons was of the order of 100 Mev, but cloud chamber measurements showed the energy of some of them to be 200 Mev. This was truly a remarkable beam of neutrons.

Various substances were placed in the path of the beam and it was soon evident that these high energy neutrons produced fission in a number of heavy elements, including lead and bismuth.

Various other interesting phenomena were disclosed. By placing small disks of graphite across the beam and measuring the induced radioactivity, Helmholz, McMillan and Sewell were easily able to map out the shape of the beam with considerable precision. They established the fact that the neutron's rays were largely confined to an angular spread of about ten degrees in the direction of the 200 Mev deuterons striking the cyclotron target. This interesting result was not entirely unexpected.

A deuteron consists of a neutron and a proton held together with a binding energy of about 2 Mev which is quite negligible compared with the kinetic energy of the deuterons striking the target. Thus, in effect, the collision of a 200 Mev deuteron with an atomic nucleus would be much the same as the simultaneous collision of a 100 Mev neutron and a 100 Mev protron. In other words, the particles are held together so loosely in the deuteron that in a nuclear collision they are "on their own."

With these considerations in mind it is easy to see that sometimes in a collision, the proton might just scrape a nucleus while the neutron would miss it altogether, thus, in view of the loose binding, proceeding on its way in a straight line with the velocity it had at the instant of the collision. According to Professor Serber[10] this is without doubt the process responsible for the beam of high energy neutrons. The action is illustrated in Fig. 9.

Serber worked out in detail the expected angular distribution of the neutron beam produced in this way. He pointed out that the neutron and the proton in the deuteron in effect are not at rest relative to their center of gravity but have essentially a vibrational energy of some 2 Mev. In quantum mechanical terms, the particles would be said to have "an intrinsic uncertainty in momentum" while in old fashioned mechanical terms, one would describe the deuteron as made up of two heavy balls (neutron and proton) oscillating back and forth, held together by an elastic spring. Therefore, according to Serber, the expected distribution of velocities of the neutrons released on collision of the deuterons in the target would be given simply by adding their intrinsic velocity distribution to the velocity of the deuteron as a whole at the instant of collision. Calculations made in this way gave a theoretical distribution in excellent agreement with the experimental observations.

Protons are Bent in Circles

On the other hand, if in a nuclear collision the neutron of the deuteron just hits the nucleus, the proton will proceed on with the velocity it had at the instant of impact and so a beam of protons would also be expected from the cyclotron target. Such "charged" particles, of course, would not proceed out from the target in a straight line like the neutrons, for they would be bent in the cyclotron magnetic field in circles half the diameter of the target deuterons. This is illustrated in Fig. 10.

Thus it was expected that protons would be observed bent to the central region of the cyclotron with energies in the range of 100 Mev and needless to say, they were immediately observed.

It is not possible in this article to comment on all the various new facts which are being disclosed by the operation of these powerful accelerating devices, but one thing should be mentioned. When the 184 in. synchro-cyclotron was started a little over a year ago, the scientists at the University of California were curious as to the radioactive isotopes that could be produced by the high energy particles, so they made a quick check of the activities produced by various bombarded targets. As recounted by Dr. Lawrence, they were confronted with a delightfully bewildering complex of radioactivities for it appeared that practically every chemical extraction showed several decay periods. With their extensive experience in the field, they were able to proceed rapidly in identification of a large number of activities, some of which indicated that more than 20 nuclear particles had been knocked out.

Also, they were interested to know whether bombardment by these high energy projectiles would result in fission of the nuclei. Again the observations were interesting to the point of bewilderment, as bombardment of heavy elements such as uranium, bismuth, and lead produced not only what were evidently fission products, but also a great many other radioisotopes over almost the whole periodic table.

Billion Volt Units?

What the future holds in the way of developing still higher energies can only be guessed at, but judging from what has been accomplished in the last ten years, it is almost certain that much higher energy projectiles will become available. The very richness of the atomic phenomena already apparent in the 100 Mev level points to even greener fields in the domain of billions of electron volts. Figure 11 is a diagram of the linear accelerator for protons under construction at the Radiation Laboratory of the University of California. It uses 30 radar sets and will reach 40,000,000 electron volts. If successful, seven such sections will be combined to reach 280,000,000 electron volts. A billion volt machine would be about 1000 ft long.

[10] R. Serber, Bull. Am. Phys. Soc., Vol. 22, p 6 (1947).

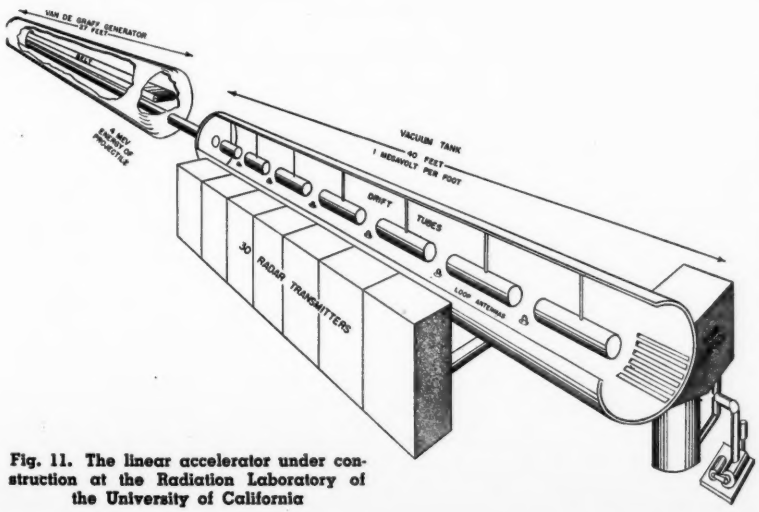


Fig. 11. The linear accelerator under construction at the Radiation Laboratory of the University of California

ASME Convenes for 68th Annual Meeting

Meeting held in Atlantic City, New Jersey, on December 1 to 5, with a registration of about 3,000 engineers from all sections of the country. Topics ranging from those which may be classified as deep science through research and on to strictly mechanical engineering problems were discussed in detail. Every branch of the mechanical engineering field was covered, including management, humanities, citizenship as well as technical subjects

By RALPH E. TURNER

MEMBERS of American Society of Mechanical Engineers have held their meetings in New York City on all but two or three occasions. The 68th annual meeting, however, was held in Atlantic City, New Jersey, on December 1-5, where in an atmosphere of sociability and good fellowship, some 3000 engineers attended the sessions devoted to the discussions of engineering subjects and society affairs without distracting business appointments and entertainment attractions that are so prevalent in New York City. In 1948, however, the annual meeting will be held in New York, when no doubt the crowded hotel conditions that were encountered during the years of the war will have been cleared up and facilities made available for large meetings like the ASME annual.

Evidence was apparent throughout the entire meeting that the engineers are making use of the discoveries of scientists as rapidly as physical and economic conditions will permit. Aviation topics were prominent in the program. The present status of the gas turbine was given detailed attention. Nuclear energy as a source of power presents many mechanical engineering problems that are being investigated by specialists in the field. A new sub-saturation reheat cycle for use with steam turbines was presented for discussion. Plants using 2000 psi, 1050 F steam and reheat to 1000 F were described. Research in such subjects as fluid meters, lubrication, properties of gases, properties of metals, sound in superheated steam, heat transfer, oil and gas power and fuels was reported in numerous papers indicating that progress in engineering for peaceful purposes has been resumed following interruption due to the war.

Sub-Saturation Reheat Cycle

Of distinct interest to the power engineer was the description of a sub-saturation reheat cycle which was presented by W. E. Caldwell, Mechanical Plant Engineer of the Consolidated Edison Co. of New York. This paper treated briefly the conditions which necessitate reheating of steam in central stations and described a method of reheating within the low pressure turbine. It compared the suggested design with conventional practice by an elementary method which gives an approximation of the economic possibilities of the cycle. It was stated that numerous attempts had been made to solve the problem of moisture in the lower stages of condensing turbines by drainage or internal modifications, with only limited success, but it is well known that reducing the moisture will increase efficiency and reduce maintenance.

It is the author's opinion that reheat is more practical in reducing moisture in the exhaust stages than increasing initial temperature, since more available heat per pound may be added within the temperature limits imposed by the physical properties of economical high temperature alloys.

The new cycle which has been investigated by the author, employs bleed steam in combination with hollow stationary blades or nozzle partitions and is termed sub-saturation reheating. Steam bled from higher stages enters the top of the diaphragm passage, blows through the lower blades to center segment, then into the upper half of the diaphragm and on down through the lower blades

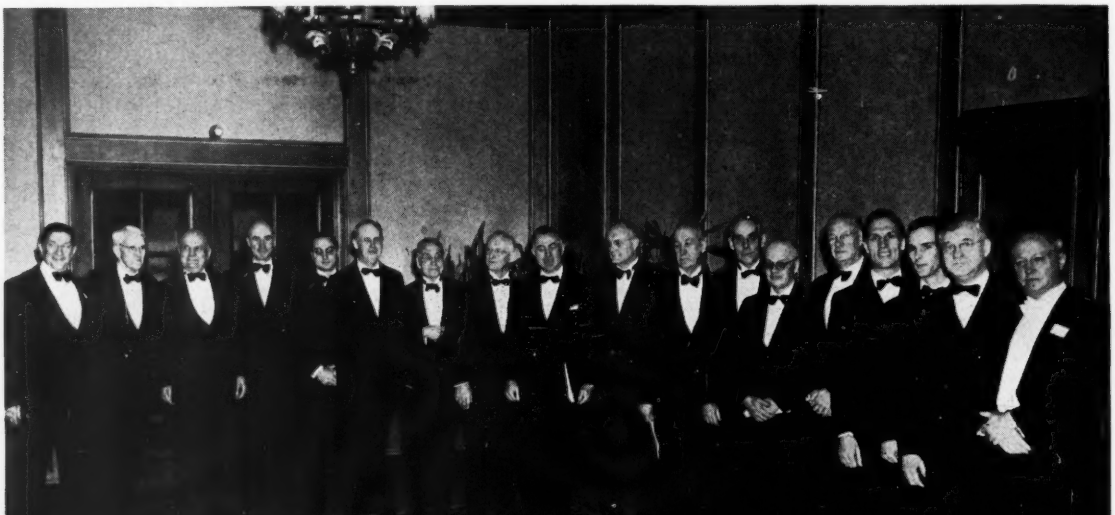


Fig. 1. Line formed for the procession to the dais as the American Society of Mechanical Engineers prepared to confer its annual honors and awards, during the Honors Night dinner. Left to right are: Ernest Hartford, C. M. Allen, L. W. Wallace, Dr. Jacob P. Den Hartog, Dr. R. C. Martinelli, Paul W. Kiefer, Dr. Francis Hodgkinson, E. G. Ackart, Eugene W. O'Brien, Dr. Blake R. Van Leer, E. G. Bailey, Dr. Harvey N. Davis, Dr. Arpad L. Nadai, Alvin E. Dodd, David Cochran, Wm. R. Collier, Clarence E. Davies, and J. M. Todd

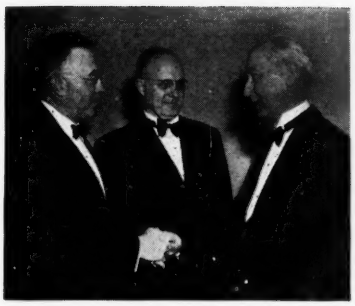


Fig. 2. Eugene W. O'Brien, retiring President of the ASME; Dr. Blake R. Van Leer, President of Georgia School of Technology, toastmaster at the Honors Night dinner; and E. G. Bailey, President of the Society for the coming year

to the bottom grates. The condensate would be discharged at the temperature corresponding to the heating steam pressure to re-enter the feed cycle. No external piping of apparatus is necessary other than the condensate drain connections.

In the use of bleed steam, reheating within the turbine, it is not the intent to superheat the steam as it is only necessary to evaporate excess moisture as it is formed. Below the dew point, moisture increases about 2 per cent per stage and the evaporative capacity of the heated nozzles is adequate for this duty.

Features of a High Pressure Plant

In summarizing his paper on the 2000 psi, 1050 F and 1000 F reheat cycle at the Philip Sporn and Twin Branch steam electric stations, Philip Sporn, president of the American Gas and Electric Service Corp. stated that the economical generation of steam electric energy is effected by such factors as site, fuel, cycle and equipment. The discussion of these basic factors served as an introduction to a description of the program involving the addition of 525,000 kw of generating capacity to the central system of the American Gas and Electric Co. at the Tidd, Philip Sporn and Twin Branch steam electric stations. The discussion of the design employing 2000 psi, 1050 F initial temperature with 1000 F reheat at the Philip Sporn plant included the location of the plant on the system, features of the site, the heat cycle, turbine, water, and plant layout. A net plant heat rate of 9270 Btu per net kwh output is expected.

The Philip Sporn Station, scheduled for completion in 1950, at Graham Station, W. Va., is part of a program involving the addition of 525,000 kw of generating capacity to the central system of the American Gas and Electric Co. It is stated that the boiler efficiency expected is 90 per cent and that the reheat cycle adopted produces a kwh for 5 per cent less coal than a straight regenerative cycle using the same pressure and temperature. The first cost is only about 2 per cent higher. The boiler is designed for maximum continuous steam output of 935,000 lb per hr at 2035 psig, 1050 F at the superheater outlet. Temperature of 1050 F will be maintained between 850,000 and 925,000 lb per hr by an attemperator between the primary and secondary portions of the superheater.

Fuels for Industries

No problem in engineering offers more diversified interest than that of securing and using fuels for industry, and many phases of the problems involved were discussed in detail at this meeting. It was said by Fred S. McConnell that the bituminous coal industry today is on the threshold of a technological revolution which will expand its usefulness in industrial civilization. Gasoline, fuel oil, and high heat value gas manufactured from coal are in prospect to augment our petroleum reserves "The bright future for coal," he said, "is not limited by what may happen in the development of synthetic fuels. Our solid fuel markets of the future present an encouraging picture." It is expected that the first experimental coal-burning gas turbine locomotive should be ready for testing on the railroads late in 1948, and this will have a great potentiality in railroad, stationary and marine power. This offers the first opportunity to burn bituminous coal with high thermal efficiency in a power plant which requires no water.

Power plant engineers in industrial plants found interest in a paper delivered by Otto de Lorenzi of Combustion Engineering Co. under the subject, "Furnaces for By-Product Fuels." It was stated that present day costs of standard fuels such as coal, oil and gas have advanced to a high level and concepts must now be revised regarding so-called refuse fuels. Their value as low-cost substitute fuels for steam generation will depend largely upon the manner in which they are prepared and upon the use of suitable furnace designs. A number of furnace designs have been developed to handle by-product fuels from oil refining operations and the manufacture of steel, coke, lumber, pulp and sugar. Others are still in various experimental stages and many improvements in methods of drying, feeding, and burning fuels will be presently available. The characteristics of several of these fuels were discussed in the paper and actual furnace designs illustrated the manner in which they are used to provide process steam and save fuel dollars.

In order to determine the effect of pressure on the combustion of pulverized coal, a series of tests was run in a furnace built for that purpose at the Battelle Memorial Institute and the results were related in a paper by Herbert R. Hazard and Fred D. Buckley. This series of tests included tests on three sizes of burners over a pressure range from 2 psi to 75 psi and over a firing range from 40 lb of coal per hr to 130 lb of coal per hr.

In discussing the present status of the synthetic liquid fuels in the United States, W. C. Schroeder of the Bureau of Mines was emphatic in his statement that the establishment of a synthetic liquid fuels industry in the United States to augment present petroleum resources should not be delayed until an emergency period. To build a capacity of 1 to 2 million barrels of synthetic liquid fuel daily, would require several years and large amounts of steel and other construction materials and manpower, he said. The program would be about 5 to 10 times the magnitude of the synthetic rubber program during the war.

Atomic Energy

An attractive feature among the exhibits displayed at the meeting was a demonstration of nuclear fission as it occurs in an atomic pile with striking visual and sound devices activated by the actual breaking up of single uranium atoms which helped to draw the attention of engineers to their part in the development of atomic energy.

The need for engineers in this new field was also stressed by David E. Lilienthal, Chairman U. S. Atomic Energy Commission, in a luncheon address entitled, "Atomic Energy and The Engineer."

He pointed to three reasons why engineers have special interest and particular responsibility in respect to atomic energy; these were: first, here is a new growing industry and a huge one, the atomic materials industry, largely built and operated by and presently being improved through engineering skills; second, looking ahead, here is a vast new field of technical knowledge opening up before your very eyes, at a rate that is probably without precedent. Your fellow citizens look to you for the manifold applications of this new knowledge, for such is the traditional role of the engineer; third, atomic energy is not only science and engineering; it is one of the most vital of all areas of public policy in which as a people we must make decisions affecting the course of the Republic, the peace of the world, and the future of our 20th Century.

In defining the field of nuclear engineering, John R. Huffman of the Clinton Laboratories, Oak Ridge, Tenn., said, "paradoxically, nuclear engineering is not particularly interested in nuclear power. As long as this power has to be obtained through the path of heat, which is the case in the present state of scientific knowledge, there are plenty of engineers well versed in power plants, turbines and the like, to design the power machinery. The duty of the nuclear engineer, insofar as he is a specialist, could end therefore with the method

of producing the desired temperature level in a satisfactory heat transfer medium.

Gas Turbines

Evidence on every hand points to early application of the gas turbine as a power generating unit. The immediate objective appears to be devising and designing equipment that will compete economically with power generating equipment that is now dominating the field. In one paper presented at the meeting it was stated that during the present pioneering development of the gas turbine prime mover system, comparatively little attention has been given to the development of light weight compact heat exchanger components, primarily the regenerator.

A vast amount of study has been given to the design of centrifugal compressors which are an essential element of the gas turbine system. And it is noteworthy that several papers dealing with them were delivered at this meeting.

Basic thermodynamic investigations by John Kreitner and Frederick Nettel were reported leading to a new general thermodynamic cycle. It was stated that the combustion turbine, under which name may be included the gas turbine in its several forms, (open cycle, closed cycle, semi-closed cycle) as well as air turbines and turbines using other gases, is growing in stature at a rate unprecedented in power history. Considerable thought, therefore, should be given to the thermodynamic foundations on which these turbines rest.

Diesel Fuels

Diesel engines, in some of their applications such as busses, trucks, tractors, locomotives, are running into criticism from the smoke abatement authorities and this problem has been under investigation by Diesel experts who lay the trouble principally to fuels. At this meeting two papers were presented which have a bearing on the problem. One of these was entitled, "Problems Associated with the Use of Diesel Fuels," by W. L. H. Doyle and E. W. Landen. The paper presented results of a recent investigation dealing with the nature of exhaust products resulting from combustion of Diesel fuels, particularly those products composing smoke. These findings together with knowledge gained from extensive research work in the field of Diesel engine combustion, demonstrate the significant influence of chemical composition and of some properties of Diesel fuels on Diesel combustion. This is related to some of the properties used for defining the various classes of Diesel fuels with the object of emphasizing factors which appear to need further development. The authors suggested the development of some new inspections for improved control over certain properties of Diesel fuels.

Studies have been carried on at the Bureau of Mines station in Pittsburgh, Pa., to determine the relative relation between aldehyde content of Diesel exhaust gas and the odorous and irritating properties of that gas, and also to determine the effectiveness of different scrubbing media for removing aldehydes from Diesel exhaust gases.

Heat Transfer

The field of heat transfer in industry is continuously expanding and each year new problems present themselves for discussion. This meeting was particularly productive of information along this line and many subjects were treated here for the first time.

In a paper by Townsend Tinker an analysis was given of the fluid flow pattern on the shell side of a heat exchanger and a new method of evaluating the mass flow through the heat transfer surface was developed. The method ties leakage, by-pass and flow characteristics directly to the dimensions and clearances of the exchanger.

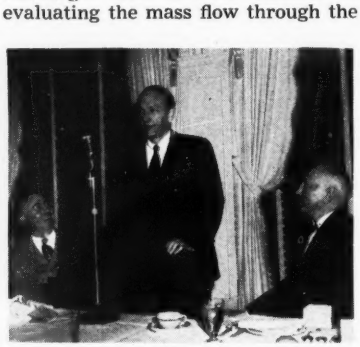


Fig. 3. David E. Lilienthal (center), Chairman of the U. S. Atomic Energy Commission, addressing ASME in Atlantic City. Shown with him are: Eugene W. O'Brien (left), of Atlanta, retiring president of the society; and Alex D. Bailey, of Chicago, chairman of its Nuclear Energy Application Committee

Heat transfer in the refrigeration industry was also given attention when a description was given by R. E. White of an apparatus designed to permit the determination of heat transfer co-efficients of condensing vapor films on the outside of tubes of sub- and superatmospheric pressures and under such ideal conditions as to permit checking the Nusselt equation. Also, it was reported by D. L. Katz and J. M. Geist that condensing heat transfer co-efficients for Freon 12, butane, acetone and water were obtained for six horizontal finned tubes in a vertical row. The over-all heat transfer co-efficients were measured for each tube at a series of water velocities and were plotted by the method of Wilson to obtain the condensing co-efficients.

With the advent of forced circulation boilers the question of heat transfer has been raised and at this meeting there was presented by R. C. Martinelli and D. B. Nelson a tentative method for the rapid calculation of pressure drop during forced circulation boiling of water. The method was based on the application of pressure drop data obtained during the isothermal flow of air and various liquids to the evaluation of local pressure gradients during forced circulation boiling. The curves developed by means of which the pressure drop during boiling can be quickly estimated once the exit quality, the boiling pressure, and the pressure drop for 100 per cent liquid are known. The proposed method, it was stated, is definitely an extrapolation of existing data and, as such, requires further experimental verification.

Progress in Metals

For many years industrial processes and machine developments were delayed because suitable metals were not available. Recognition of this need stimulated metallurgists to develop alloys for specific purposes so that today credit for advanced efficiencies may, in many instances, go to the metallurgists who have made available metals that will withstand higher temperatures and stresses, offer greater resistance to acid corrosion and erosion conditions, that are lighter in weight in comparison to volume and strength, and permit more convenient methods of working and fabrication. At this meeting the latest developments in submerged and gas shielded electric welding used in construction and maintenance of equipment was brought to the attention of engineers by Norman G. Shriner, who went considerably into detail regarding this process of welding.

Graphitization of piping which during the past few years has been given considerable attention was further investigated during the past year, and it was stated by A. M. Hall and S. L. Hoyt that the test program is still being worked upon. Carbon-molybdenum, chromium-molybdenum, and vanadium-molybdenum compositions were tested at 1125 F. An effort was made to relate plastic deformation with graphitization on the laboratory basis. The high resistance of chromium-molybdenum steels was confirmed.

Outstanding among the many fine papers of general interest to engineers was the address by President Eugene W. O'Brien at the annual dinner. His talk was entitled "Accent on Youth." The theme as he stressed it was "The production of men, of personnel—the production of engineers of proper temperamental and personal background, as well as technical background—engineers who can lead us to the greater productive possibilities which we talk about so impersonally, and impassively, all

this week. And I don't mean the production of engineers such as we older men profess to be, with such smug satisfaction. I have in mind the production of engineers who on the average are not so deeply imbedded in rigid technical laws and flexible formulas, nor so entangled within a rigid technical structure that they cannot be averagely human, that they cannot mix with and understand other people. We older engineers have served well in utilizing the materials of nature and in controlling its forces, but we have done poorly indeed in that other major function of our job as engineers —the directing and influencing and servicing of human nature."

He went on to state that young engineers are telling the Society what certain things they want. First of all they want action, not merely reports and surveys. They want protection—protection against unionism, protection against trade school engineers, as they call them, protection against the public opinion which does not give the engineers his full due, and protection against an economic system that does not give him his full pay. They want educational guidance from practicing engineers, both in school and more important in the years immediately after school. They want unification of the profession and of its organizations. They often don't know what to join. They want the profession and the society to take an active human interest in them and participation in what they are doing."

PARTIAL LIST OF PAPERS PRESENTED AT THE 68TH ANNUAL MEETING OF THE ASME, SELECTED FOR THEIR INTEREST TO POWER ENGINEERS:

Stability of SR-4 Electric Strain Gages and Methods for Their Waterproofing and Protection in Field Service, ALEXANDER BOODBERG.

Development of an Air-Operated Force-Measuring System, A. A. MARKSON and RAY S. WILLIAMS.

Frequency Response Measurements of a Hydraulic Power Unit, M. RUSSELL HANNAH.

Continuous Determination of Oxygen Concentration Based on the Magnetic Properties of Gases, ROBERT D. RICHARDSON.

Shell Side Heat-Transfer Characteristics of Segmentally Baffled Shell-and-Tube Heat Exchangers, TOWNSEND TINKER.

Heat Transfer and Fluid Friction During Viscous Flow Across Banks of Tubes, GEORGE A. OMOHUNDRO, A. P. COLBURN, and O. P. BERGELIN.

A Study of Flow Patterns in Baffled Heat Exchangers, SIGMUND KOPP, H. R. SENNSTROM and A. Y. GUNTER.

The Effect of Baffle Height and Baffle Clearance on Heat Transfer and Pressure Drop in Heat Exchangers, B. E. SHORT.

Hydraulic Problems in Connection with the Design of the Granby Pumping Plant, ELIOT B. MOSES.

Pumping Requirements for Irrigation on Columbia Basin and Central Valley Projects of the Bureau of Reclamation, IRVING L. WIGHTMAN.

Problems Associated with the Use of Diesel Fuels, W. L. H. DOYLE.

The Removal of Aldehydes from Diesel Exhaust Gas, ROGERS F. DAVIS and M. A. ELLIOTT.

Construction and Maintenance of Railroad Equipment by Submerged and Gas-Shielded Electric Welding, NORMAN G. SCHREINER.

Notes on the Design and Construction of Staybolted Locomotive Fireboxes, F. P. HUSTON.

Sanitary Engineering Equipment for Water, Sewage, and Waste-Treatment Plants, JOSEPH J. GILBERT.

A Subsaturation Reheat Cycle, W. E. CALDWELL.

An Experimental Determination of Sound in Superheated Steam by Ultrasonics, JAMES WOODBURN.

Atomic Energy and the Engineer, DAVID E. LILIENTHAL.

Heat Transfer in Industry, CHARLES E. LUCKE.

Laboratory Investigations of the Mechanism of Cavitation, R. T. KNAPP.

The Hydrodynamics Laboratory at the California Institute of Technology, R. T. KNAPP, JOSEPH LEVY, F. BARTON BROWN, and J. PAT O'NEILL.

Mechanical Activation — A Newly Developed Chemical Process, M. C. SHAW.

Nuclear Engineering—Basic Design Background, JOHN R. HUFFMAN.

A Design Method for Counterflow Shell-and-Tube Heat Exchangers for Gas Turbines, D. G. SHEPHERD.

Heat Exchanger Tube Sheet Design, KARL A. GARDNER.

Economies in the Handling of Materials in Industry, HARRY E. STOCKER.

The Coal Industry Looks Ahead, FRED S. MCCONNELL.

A Numerical Solution for the Torsion of Hollow Sections, EDWARD C. COLIN.

On the Use of Power Laws in Stress Analysis Beyond the Elastic Range, ALICE WINZER and WILLIAM PRAVER.

Approximate Solutions for Symmetrically Loaded Thick-Walled Cylinders, C. W. MACGREGOR and L. F. COFFIN, JR.

Ignition and Flame Stabilization in Gases, BERNARD LEWIS and GUENTHER VON ELBE.

High-Output Combustion of Ethyl Alcohol and Air, A. H. SHAPIRO, D. RUSH, W. A. REED, D. G. JORDAN, and GEORGE FARNELL.

The Influence of Reaction Interface Extension in the Combustion of Gaseous Fuel Constituents, W. J. WOHLENBERG.

Condensation of Refrigerant Vapors—Apparatus and Film Coefficients from Freon-12, ROBERT E. WHITE.

Condensation on Six Finned Tubes in a Vertical Row, D. L. KATZ and J. M. GEIST.

Materials Handling in the Distribution Department of the Telephone Division of the Western Electric Co., F. C. PODBOY.

Lower Overhead and Larger Pay Checks Through the Application of Wage Incentives to Material Handling Operations, H. B. SHAW.

Engineering for Aluminum Alloy Castings, H. J. ROWE and T. R. GAUTHEIER.

Magnesium Castings, Their Production and Use, M. E. BROOKS, and A. W. WINSTON.

A Clinical Approach to Weldment Design, GERALD VON STROH.

Production of All-Welded Tractor Frame and Clutch Case, CHARLES A. DAVIS and WILFRED C. CADWELL.

The 2000 psi, 1050 F and 1000 F Reheat Cycle at the Philip Sporn and Twin Branch Steam Electric Stations, PHILIP SPORN.

Predication of Pressure Drop During Forced-Circulation Boiling of Water, R. C. MARTINELLI, and D. B. NELSON.

Discussion of Heat Transfer Film Theory, BENJAMIN MILLER.

Gas-Turbine Plant Combustion - Chamber Efficiency, A. L. LONDON.

Temperature Measurements and Combustion Efficiency in Combustors for Gas-Turbine Engines, WALTER T. OLSON and EVERETT BERNARDO.

The Determination of Gas-Turbine Combustion-Chamber Efficiency by Chemical Means, PETER LLOYD.

Co-ordinating Materials Handling with the Manufacturing Cycle, S. C. HOEY.

Material Control and the Handling of Inventory, F. C. WINTER.

Analysis of Compressor Design, A. J. JADOT.

Axial-Flow Compressors for Gas Turbines, A. I. PONOMAREFF.

A Method of Correlating Axial-Flow Compressor Cascade Data, HUNT DAVIS.

Furnaces for By-Product Fuels, OTTO DE LORENZI.

Experimental Combustion of Pulverized Coal Atmospheric and Elevated Pressures, H. R. HAZARD.

Current Definitions of High- and Low-Heat Values of a Fuel and Current Methods for Their Determination, E. F. FIOCK, RALPH JESSUP and FILLMER W. RUEGG.

Current Definitions of Thermal Efficiencies and Current Usage of Observed Fuel Heat Values and Consumption Test Data for the Evaluation of Thermal Efficiencies Reported for (a) Steam and (b) Internal-Combustion Power Plants, A. G. CHRISTIE.

Discussion of Procedures for Evaluating Energy, Temperature, and Pressure Relations Based on Precise Knowledge of Thermodynamic Properties of the Gases Resulting from the Combustion of Fuel in Thermal Devices, Including Gas Turbines, R. V. KLEINSCHMIDT.

Mechanisms of Combustion and Their Relation to Oil-Burner Design, HAROLD R. HEIPLE, SR., and WILLIAM A. SULLIVAN.

Synthetic Liquid Fuels in the United States, W. C. SCHROEDER.

Analysis of Tests on Positive Displacement for Meters for Liquid Hydrocarbons, E. E. AMBROSIUS.

High Pressure Gas Measurement, E. E. STOVALL.

Oscillating Piston Meters for Fuel Consumption in Aircraft, CHARLES S. HAZARD.

Discussion of Transmission Systems for Marine Propulsion of Gas Turbine Power Plants, W. E. HAMMOND.

The Universal Optimum Power Cycle for Elastic Fluid Turbine Power Plants, JOHN KREITNER and FREDERICK NETTEL.

Plastic Tooling Comes of Age, LAWRENCE WITTMAN.

Major Plastics Developments During 1947, J. W. UNDERWOOD.

Why Pollution Abatement Concerns the Mechanical Engineer, J. RAYMUND HOFFERT.

Waste Disposal Problems from Oil Refineries, W. B. HART.

Technical and Economical Aspects of Water Purification for Ships, R. V. KLEINSCHMIDT.

Low Pressure Steam Heated Marine Distilling Plants, A. M. IMPAGLIZAAO and ROBERT M. BENT.

Oil Elimination from Feedwater, MORRIS BRADT.

Demineralization Processes, D. J. SAUNDERS.

Silicone Rubber—New Properties for Design Engineers, GEORGE S. IRBY, JR., WYMAN GOSS, and JAMES J. PYLE.

Rubber in the Automotive Industry, ROBERT K. WILLIAMS.

Advances in Rubber During 1947, V. A. CASLER and S. W. MCCUNE, III.

A Gas-Turbine Development Laboratory at Westinghouse Electric Corp., W. R. NEW.

An Aircraft Gas Turbine for Propeller Drive, ALAN HOWARD, and C. J. WALKER.

Generalized Thermodynamics of High Temperature Combustion, HOYT C. HOTTEL, G. C. WILLIAMS, and C. N. SATTERFIELD.

Wartime Work of N.A.C.A. on Thermodynamics, L. R. TURNER.

Thermodynamic Properties of Gas Mixtures Encountered in Gas Turbine and Jet-Propulsion Processes, JOSEPH KAYE.

Practical Lubrication Engineering, DAVID A. HALL.

An Analysis of the Full-Floating Journal Bearing, M. C. SHAW and T. J. NUSSDORFER, JR.

Oil Flow and Temperature Relations in Lightly Loaded Journal Bearing, JOHN BOYD and B. P. ROBERTSON.

Measurement of the Combined Frictional and Thermal Behavior in Journal Bearing Lubrication, S. A. MCKEE, H. S. WHITE, and J. F. SWINDELLS.

Further Investigation of the Graphitization of Piping for the E.E.I.-A.E.I.C., A. M. HALL and S. L. HOYT.

Some 1000 F Steam Pipe Materials, ERNEST L. ROBINSON.

A Study of the Properties of 0.5 Per Cent Chromium-0.5 Per Cent Molybdenum Pipe Materials, R. C. FITZGERALD, A. B. WILDER, G. V. SMITH, and A. E. WHITE.

The Structural Stability of Several Cast Low Alloy Steels at Elevated Temperatures, VINCENT T. MALCOLM.

Studies in Boundary Lubrication II—The Influence of Adsorbed Moisture Films on the Coefficient of Static Friction Between Lubricated Surfaces, W. E. CAMPBELL and E. A. THURBER.

High Temperature Performance of Silicone Fluids in Journal Bearings, J. E. BROPHY, JOHN LARSON, and R. O. MILITZ.

The Hydrosphere—A New Hydrodynamic Bearing, M. C. SHAW and CHARLES D. STRANG, JR.

Estimating Voltage Drops Caused

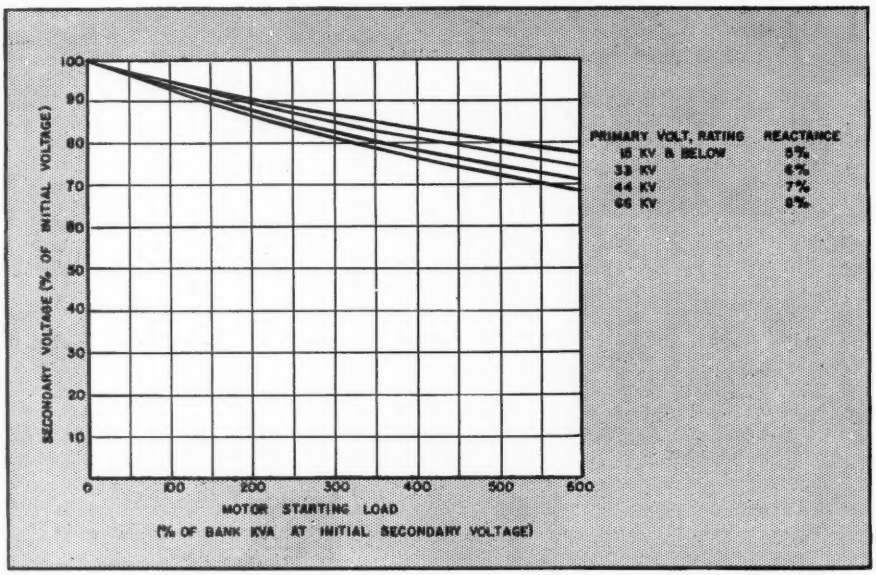


Fig. 1. Transformer secondary voltage for starting loads of pf below about 0.4

WHENEVER a motor is started, a voltage drop occurs in its power supply system. Some of this drop occurs in the generators, and some in transformers, lines, and cables between the generators and the motor starter.

The voltage drops in lines, cables, and transformers are often as important as generator voltage drop. In fact, they are frequently more important. For example, if the total kva of connected generators in the power system is more than 100 times the hp rating of the motor being started, then the generator voltage dip will be less than 1 per cent, and it will be quickly eliminated by regulators. In such a case, however, the motor will probably be supplied through a transformer bank. If the bank kva rating is only slightly larger than the motor rating, the voltage drop may be quite severe.

Transformer Voltages

Figure 1 shows the per cent secondary voltage of typical transformers of several voltage ratings. The secondary voltage is plotted in terms of motor starting load. This is expressed in per cent of transformer bank kva rating, and is the load which would be drawn if the initial secondary voltage were maintained.

The curves of Fig. 1 neglect the effect of primary voltage drops caused by motor starting. Methods of taking these into account will be explained later.

It should be noted that secondary voltage is plotted in per cent of its initial value. This initial voltage is determined by the initial primary voltage, tap setting, and the initial load. It may be determined by measurement, or by suitable calculations. It is usually slightly less than the rated secondary voltage.

Cable and Overhead Line Voltage Drops

The per cent voltage at the load end of cables is illustrated by Fig. 2 and 3. In using these figures, it is necessary to first determine the motor starting load in kva, the circuit length in feet, and the initial voltage at the load end of this circuit. These factors are combined to obtain the loading factor, M, as follows:

$$M = (\text{Motor starting kva}) \times (\text{Ft of Circuit length}) \div (\text{initial voltage})^2$$

For example, if the motor starting load were 1000 kva, the circuit 1000 ft long, and the initial voltage were 2400 v, the loading factor, M, would be

$$\frac{1000 \times 1000}{(2400)^2} = 0.173.$$

Figure 2 shows that for this case, the voltage drop at the load end of a typical 3-conductor cable is 1.5 per cent. (Drop = 1.5 per cent on Curve A at M = 0.173)

This figure gives data for three circuits, a 3-conductor cable, a single-conductor cable, and an overhead line. It will be noted that the voltage drop in an overhead line is greater than that for a cable.

If two circuits are in parallel, the drop is equal to that for a single circuit of one-half the actual length of each circuit.

The voltage drop in a line or cable depends upon the conductor size and spacing. Consequently, for different cases than those illustrated in Fig. 2, the voltage drop may be somewhat different. This is illustrated by Fig. 3, showing the voltage drop for a range of circuit configurations. The points corresponding to the circled cases of Fig. 2 are circled on Fig. 3.

Figure 3 applies for the condition, M = 1.0. It may be noted, however, that the curves of Fig. 2 are nearly straight lines. Hence, approximately, the voltage drop for other values of M may be estimated by multiplying the values of Fig. 3 by M. This provides a simple method of estimating the voltage drop for motor starting loads.

The power factor of the motor starting load is assumed to be 0.3 pf. For conductor sizes above AWG-O, variations over the usual range from 0.2 to 0.4 will not importantly affect voltage drop.

Figures 2 and 3 are based on a frequency of 60 cycles per second. Lines and cables for systems operating at lower frequencies will have less voltage drop. The voltage drop will be reduced approximately in proportion to the frequency for all conductor sizes above No. 0. For smaller sizes, the reduction will be less.

Reactors

The drop in a current-limiting reactor may be estimated if the per cent reactance on a specified kva rating is known. The curves of Fig. 1, for transformers, may then be used for estimating reactor drop.

Series Capacitors

It is sometimes advantageous to include series capacitors in the dis-

by Starting A-C Motors

Part II. In this article Mr. Boice continues his discussion of voltage drops caused by the starting of a-c motors. Here he analyzes the distribution system voltage drops—those involved in transformers, cables and overhead lines and the effect of series capacitors where they are used. He also considers power systems consisting of complex networks, the effect of combined voltage drops of circuits in series and in parallel. The question of motor torque also enters the picture, the motor torque-speed, and torque-load characteristics, but these matters will be considered in the third and last part of this article

By W. K. BOICE

Industrial Power Division, General Electric Co., Schenectady, N. Y.

tribution system to neutralize the reactance of lines, cables, or transformers. By doing this, series capacitors reduce voltage drop. The amount of reduction depends upon the capacitor rating. The selection of series capacitors, and calculation of their effects, is beyond the scope of this article.

Power Systems

Motors are frequently supplied from power systems consisting of complicated networks of lines and cables for which a calculation of the voltage drop would be difficult. The voltage drop may be estimated, however, if the short-circuit current is known at the point of power delivery.

The short-circuit current is usually expressed in kva.

When a motor starting load is applied to a power system, the system voltage drop is equal to 100 per cent times the motor starting kva divided by the sum of this kva and the short-circuit kva. For example, if a 1000-hp motor having a starting kva of 5000 is started across the line of a system having a short-circuit kva of 50,000, the voltage drop will be 9 per cent (because

$$\frac{5000 \times 100 \text{ per cent}}{5000 - 50{,}000} = 9 \text{ per cent})$$

This formula allows for the decrease in load caused by the voltage drop.

Table I, Part I, shows the usual short-circuit kva for several system voltages. Of course, the minimum value is the most important for motor starting, since smaller short-circuit kva means larger voltage drop.

Series Circuits

Often a motor is supplied through cables, transformers, overhead lines, and generators, all in series. In such cases, the total voltage drop may be roughly estimated as the sum of the voltage drops given by the foregoing figures for each of the different parts of the system. However, the simple addition of voltage drops is not quite accurate because addition of impedances in series tends to diminish the current supplied to the motor.

For more accurate work, the following procedure is suggested:

1. Determine the voltage drop in the circuit element nearest the motor, neglecting the other elements. (For example, for a motor supplied from a generator, transformer, and cable in series, determine the drop in the cable first.)

2. Reduce the applied kva in proportion to the voltage drop just determined.

3. Using this new value of applied kva, calculate the voltage drop in the next circuit element. (In the example selected, this is the transformer drop.)

4. Reduce the applied kva again in proportion to the voltage drop last determined.

5. Continue process until all elements in series have been considered.

6. Multiply the values obtained for the per cent voltage at the load terminals of each element. This result is the final voltage at the load.

Parallel Circuits

If several sources are in parallel, the voltage drop is less than if the motor starting load is supplied through any one of them. To determine the combined drop, it is suggested that groups of similar generators may be treated as a single generator having the same total kva rating and the same performance factor as the individual machines. Transformer banks may also be grouped if they are supplied from the same primary bus and have the same per cent reactance and the same tap settings.

To find the combined drop for several parallel sources of different characteristics, it is suggested that the motor starting load be first divided equally and the corresponding voltage drops determined. Then a new trial division of load can be made so as to increase the proportion of load carried by the sources with the least voltage drop. Usually only one or two trials are required to obtain a sufficiently accurate result.

For example, consider the case of a 1000-kva motor starting load applied to a bus furnished with power

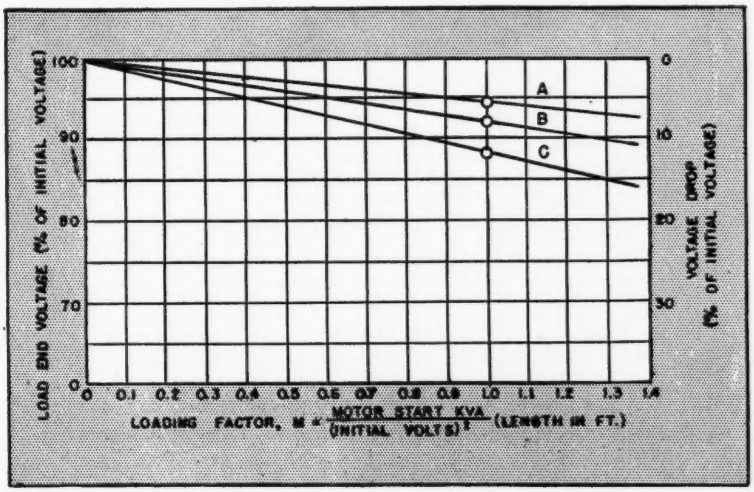


Fig. 2. Typical voltage drops in lines and cables

A—3-Conductor Cable—(4/0-15 kv)
B—1-Conductor Cable—(4/0-6 in. Spacing)
C—Overhead:—(4/0-15 kv)
(Circled points appear on Fig. 3)

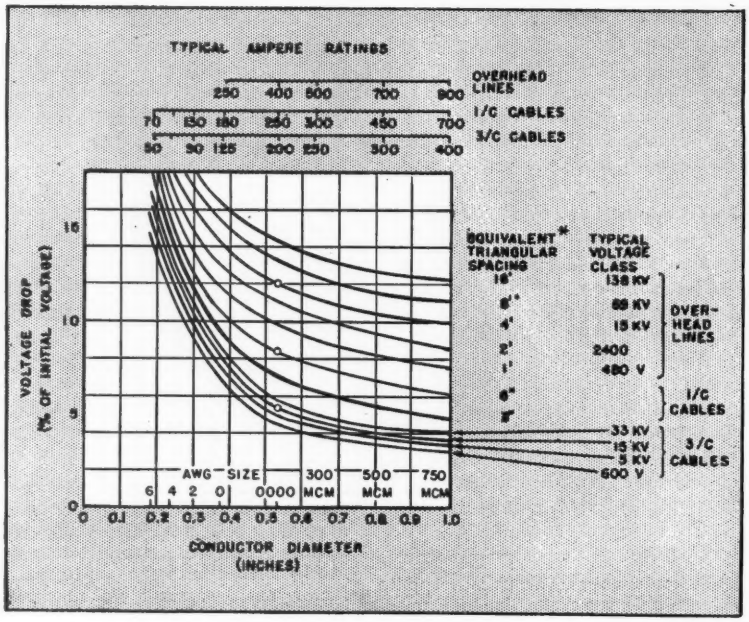


Fig. 3. Voltage drop in lines and cables
For motor starting loads (0.3 pf)

$$\text{Loading Factor } M = 1.0 = \frac{(\text{Motor Starting kva})}{(\text{Initial Voltage})^2} (\text{Length in feet})$$

For flat spacing, equivalent triangular spacing = 1.26 times spacing between adjacent phases

by a 500-kva generator and a 300-kva transformer bank. The first trial division of load will be 500-kva each. Let us assume this result in a minimum voltage of 75 per cent on the generator and 90 per cent on the transformer secondary. This means that the generator will actually accept less than half the load. The drop in the generator is 2.5 times as great as in the transformer. Let us then assume that the transformer accepts 2.5 times as much load as the generator. This results in 285 kva being accepted by the generator and the remainder, 715, being imposed on the transformer (715 is 2.5 × 285). The voltage drop in the transformer for 715 motor starting kva will be found to be practically the same as for 285 motor starting kva applied to the generator. The drop obtained is the combined voltage drop. For the case illustrated this drop is about 14 per cent.

It is advisable to make a final check of the drop through each source, because the drop in a generator does not always vary directly, with amount of motor starting load applied to it. This is especially true of the recovered voltage obtained through the action of voltage regulators.

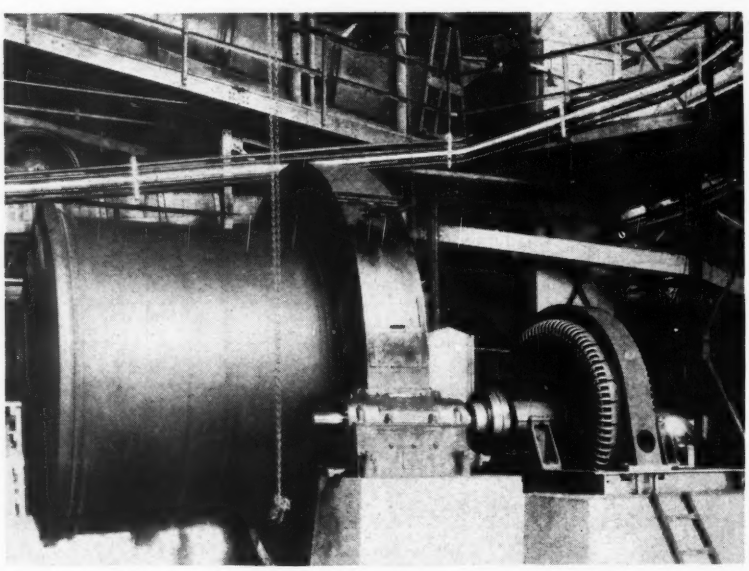


Fig. 4. Synchronous motor driving ball mill which requires high starting, accelerating and pull-in torques

Note.—This is the second part of a 3-part article. The third part will appear in a subsequent issue.

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A TINY NEW dry cell, with amalgamated zinc and mercuric oxide electrodes, is now available for many special applications. For a given capacity, under normal or heavy conditions of use, the new mercury cell is only half as heavy, and less than half as big as the conventional zinc-carbon flashlight cell, heretofore the only small dry cell generally available. Depending on the conditions of use, the advantages of the mercury cell may be even greater. With the price twice that of the conventionall cell, the operating cost per hour for many applications is about the same. Furthermore, long life is considered an important convenience, regardless of cost. It is also claimed that the mercury cell can be stored longer at high temperatures without deterioration than the older type.

The mercury cell is entirely enclosed in a cylindrical steel container, which may be from three-fifths to one and one-quarter inches in diameter and one half or five-eighths inch long. Although part of the electric circuit, the container does not otherwise enter into the cell reaction.

The voltage of the zinc-carbon cell drops off with use, as is shown by the dimming of a flashlight bulb. When the output, initially 1.5 volts, has dropped to 0.9 volt, the cell is discarded. The mercury cell, however, with light loads maintains a constant output of about 1.3 volts until exhausted. As a result, the necessity for frequent volume adjustments for a hearing aid or intercommunication system is obviated. A sudden drop in voltage may be a disadvantage, however, since the device may go out of use without warning. With a heavier load, the voltage varies from 1.3 to 1 volt, depending on the application.

In spite of the advantages of the mercury cell in some applications, the zinc-carbon cell is not expected to become obsolete. Mercury is an expensive and scarce element; the necessity for conserving the world's mercury reserves will prevent widespread use where other materials are satisfactory.

ARTHUR D. LITTLE,
Industrial Bulletin

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Corrosion in Boiler Feedwater Treating Systems — IV

This discussion refers especially to systems employing zeolite, acids, degasification . . . This article, last of four, reports tests to evaluate comparative corrosion resistance of materials used in deaerating heater trays, vent condenser tubes, water heater tubes . . . This is the fourth and last article of a series . . . Part I, October issue, outlined the pattern of corrosion in water treating systems; Part II, November issue covered graphitic corrosion of cast iron; Part III, December issue reported on performance of materials . . . Entire series is designed to show that, contrary to what many believe, there are corrosion patterns in equipment of this type; that maintenance and outages caused by corrosion in the system are important in ultimate cost; that water treating systems well engineered must contain materials giving long life and low maintenance equal to that of the steam generating equipment served

By LEO F. COLLINS *Chemical Engineer, The Detroit Edison Company*

THE TESTS reported here were designed to evaluate the comparative corrosion resistance of materials which might be used for (a) trays in deaerating heaters, (b) tubes in the vent condensers of deaerators and (c) tubes of domestic water heaters for use with Detroit city water and utilizing steam as the heating medium.

Materials of the following types were fabricated both as heating trays and air-separating trays:

1. Gray cast iron
2. Parkerized cast iron
3. Copper bearing steel
4. Nitrited steel
5. Aluminum
6. Brass
7. Clay (glazed tile)
8. Lead-coated steel
9. Tin-coated steel
10. Cadmium-plated steel
11. Alloyed cast iron (Mn 0.5 SiO_2 2, Ni 4, Cu 7)

For about 7 years, these were removed, cleaned mechanically, and weighed. The weight loss measurements, however, are not regarded as significant. More significance is attached to visual inspections.

Failure of the weight loss measurements to yield significant data is believed due to the following factors:

1. Incomplete cleaning (by scraping) and lack of precision of the weighing device. (A grocer's scale was used because of the masses that had to be weighed.)
2. Trays located promiscuously in a large heater do not always experience the same conditions.
3. The volume of metal lost and the areas from which it is lost (i.e., the holes or edges of slots) are of

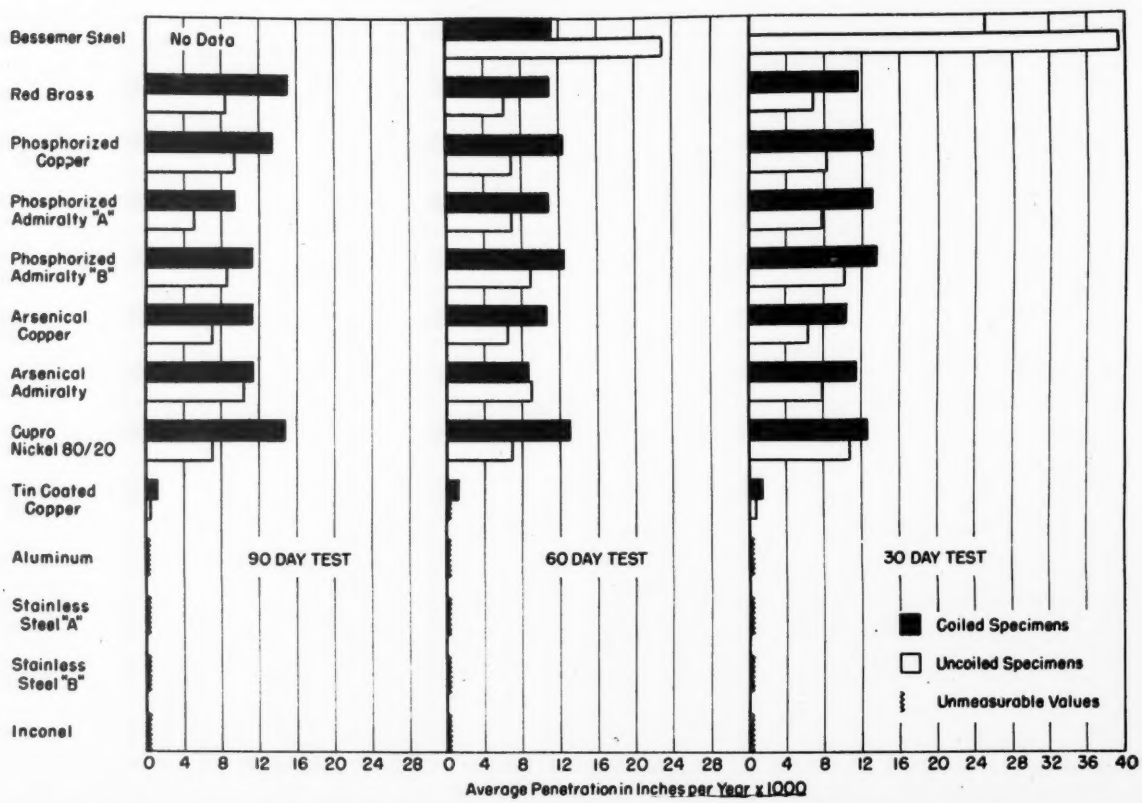
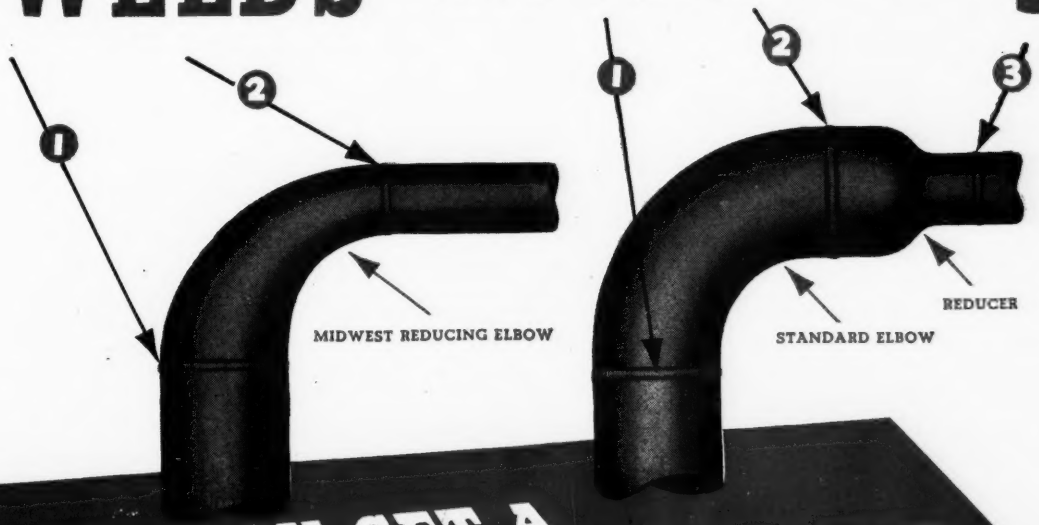


Fig. 1. Comparative corrosion resistivity of 10 materials subjected to condensate from vent condenser of a deaerating feedwater heater

2 WELDS INSTEAD OF 3



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significance but cannot be gaged by weighing the entire tray.

Visual inspection, however, revealed that air separating trays corrode at an insignificant rate as compared to heating trays. Thus, no pronounced difference was evident between any of the materials tested when fabricated as air-separating trays. For heating trays, the following was noted:

1. Gray iron corrodes at a rate slightly higher than any of the other materials.
2. Parkerizing did not materially change the corrosion characteristics of the cast iron.
3. Copper bearing and nitrited steels exhibited about the same corrosion resistivity as cast iron.
4. Erosion, rather than corrosion, of aluminum trays was pronounced at the holes and rendered them obsolete in three years.
5. Brass was also susceptible to erosion but not to the same extent as aluminum. The brass trays were discarded after about six years.
6. The glazing was removed from the tile trays after one year of operation. In some instances they cracked during operation. In general they required such careful handling as to be judged impractical.
7. Cadmium plating disappeared in one year of service.
8. Sheet lead coatings blistered and peeled in the second year of operation.
9. The alloyed cast irons showed no marked superiority over gray iron.

From these observations, it was concluded that, on a service-per-dollar basis, gray iron is the logical choice, recognizing that periodic replacements will be necessary.

Because of the field experiences (reviewed with respect to vent condenser tubes) and because it is not always possible to get a recommendation as to materials for such service from equipment vendors, the tests reported here were conducted.

For these tests, a special apparatus was designed so that wire specimens of different metallic compositions could be subjected to condensate drained from the vent condenser of a deaerating feedwater heater. The test technique embodied the principle of the NDHA corrosion tester. The results obtained are shown graphically in Fig. 1.

As a result of these tests, the tubes and tube sheets of about a dozen vent condensers are known to have been tinned. The oldest has been in service for 7 years and no failures have been reported.

On the basis of the information presented up to now, it might be reasoned that, while an important increase in the temperature of soft waters would probably increase their corrosivities to the "severe" state, this might not hold true for hard waters because such a temperature increase would bring about the deposition of a calcium carbonate film that acts protectively.

To check on this reasoning, Detroit city water from a domestic heater was led through the apparatus used in testing the condenser tube materials. The results obtained are shown in Fig. 2.

By comparing Figs. 1 and 2, it can be seen that the corrosion rate for the copper alloys in hot, hard water is about one-fifth that for the same materials exposed to condensate from a vent condenser. By comparing Fig. 2 with Table II, Part I, October issue, it can be seen that, for steel, increasing the temperature of hard water from the range of 40 to 60 F to within the range of 120 to 150 F increased the corrosion rate about eightfold.

General Summary

In virtually all engineering undertakings, it is axiomatic that design shall provide a maximum of service for a minimum investment.

In the development of boiler feedwater processing systems, the fact is sometimes overlooked that first costs do not represent the ultimate cost. Clearly, the latter includes maintenance and unscheduled outages resulting from inadequately conditioned water, as well as the initial investment.

Moreover, maintenance of water treating equipment is not always pursued with the same degree of enthusiasm as is accorded other major plant equipment. Thus there is no definite assurance that the limitations originated by corrosion will always be found and corrected at an opportune time.

For these reasons, it is felt that if a water treating system is to be well engineered, the materials specified should be chosen with a view of minimizing maintenance as well as preventing important failures during the "normal" life of the plant.

A reasonable "life expectancy" for such equipment is largely a matter of opinion. Even so, it seems reasonable to assume that it should be about equal to that of other major steam generating equipment. For the latter, some statisticians indicate an average life of about 28 years (7). See references, Part I. It is hoped that the criteria suggested in this paper will supply some of the information leading to such a result.

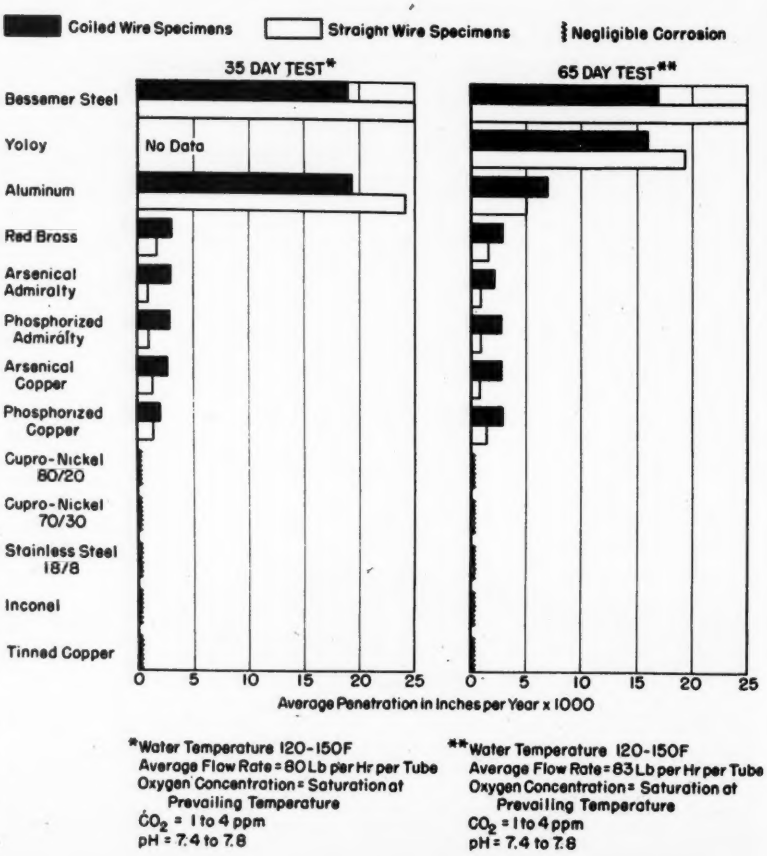

Fig. 2. Comparative corrosion resistivity of materials exposed to hot hard water

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Importance of
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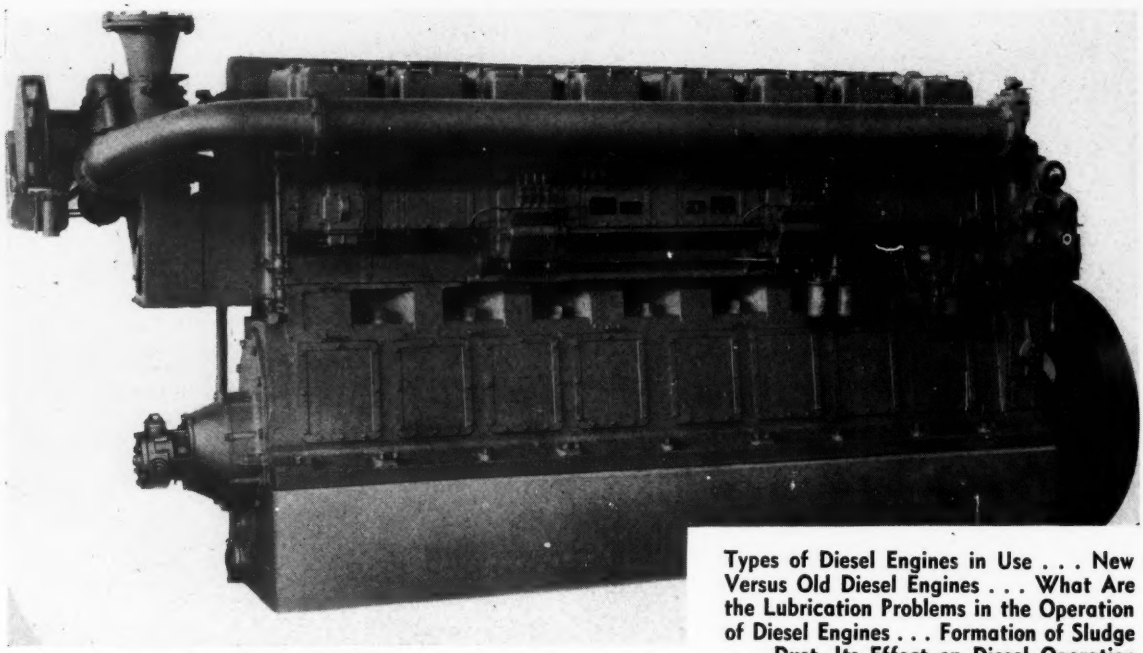

Fig. 1. An 8-cylinder Cooper-Bessemer supercharged stationary diesel engine. Bore 13 in., stroke 16 in.

Types of Diesel Engines in Use . . . New Versus Old Diesel Engines . . . What Are the Lubrication Problems in the Operation of Diesel Engines . . . Formation of Sludge . . . Dust, Its Effect on Diesel Operation . . . Factors Involved in the Operation of the Lubrication System and maintenance

By THOMAS TRAIL

IT IS ESTIMATED that 10 billion gallons of fuel oil and 100 million gallons of lubricating oil are consumed by diesel engines in this country each year. From these figures it can easily be seen that the use of this type of power is very extensive, and it is growing by leaps and bounds.

Diesel engines are built in an astonishing variety of types, sizes and styles, and ranging in capacities from a few horse power to as much as 24,000 hp.

For this reason, considerable confusion exists pertaining to the exact type of a particular engine. But this may be clarified in part by a bit of explanation. The true diesel engine, sometimes called the "full diesel", is an engine that employs the heat of highly compressed air to ignite its fuel charge. Another class of oil burning engines is often referred to as "semi-diesel." In this type ignition of the fuel charge is accomplished by auxiliary means such as electric spark or applied heat, somewhat similar to the manner in which a gasoline engine operates.

In this article we are primarily interested in larger slow speed diesels in the speed range up to 500 rpm. However, diesel engines are built in two other general speed classifications: from 500 to 1000 rpm, and above 1000 rpm.

Diesel compression ratios in this country vary from approximately 11:1 to as much as 19:1. The two general type classifications for diesel engines are the two-cycle and four-cycle types. In two-cycle operation, the fuel charge fires once in each cylinder at each revolution of the crankshaft. This means that on the down stroke of the piston the fuel charge is fired and the burned gases are expelled through exhaust ports in the wall of the cylinder. On the up stroke, fresh air, that entered the cylinder through intake ports in the cylinder walls, is compressed by the piston to the degree that it will ignite the fuel charge when it is sprayed into the cylinder.

In the four-cycle engine the fuel charge fires only once in each cylinder for every two revolutions of the crankshaft. Thus on the first down power stroke the fuel charge is fired. On the first up stroke the burned gases are expelled from the cylinder through the open exhaust valve. On the second down stroke fresh air is pulled into the cylinder through the open inlet valve. And on the second up stroke the air is compressed to ignition temperature to fire the fuel charge when it is sprayed into the cylinder.

To add to the complexity of diesel engine types they are further subdivided into solid injection and air injection; crosshead, trunk-piston, double-acting and opposed-piston styles; number of cylinders; and open combustion chamber, pre-combustion chamber, ante-combustion chamber, and separate combustion chamber types.

If the engine in question is new it can be assumed that everything is in efficient operating order, and the only problem then is to take care of the engine in such a manner as to insure a continuance of this condition as long as possible.

But where the engine under consideration has been operating for some time and it is not known just what the condition of its parts may be, nor whether the various functions are being carried out as they were

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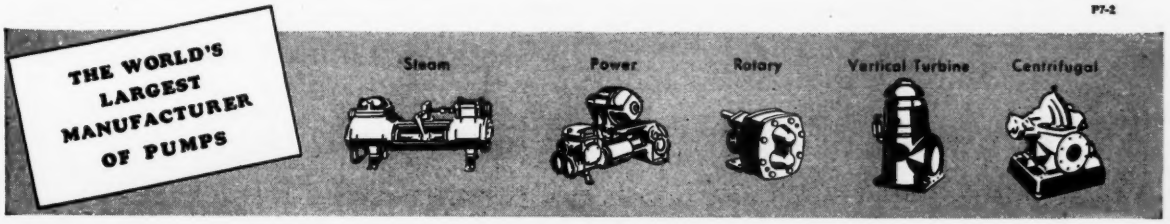

designed to be, the logical step is to first have a complete checkup made of the engine. Oil companies are in a position to furnish the necessary technical skill and instruments to carry out this task and it is well to take advantage of this service. These tests will accurately determine, for each cylinder, the peak pressure, the horse power output, the compression end pressure, the condition of the fuel nozzles, piston and ring wear, the injection timing, and the analysis of the exhaust gas. By means of modern testing equipment, the task of testing a 10-cylinder engine has been cut from days down to hours. A 10-cylinder 3000 hp engine can be completely analyzed in four hours.

When a diesel engine is in good operating condition, this is the ideal time to have a lubrication requirements checkup made by a competent lubrication engineer. The services of such a specialist may readily be obtained from any one of a number of oil companies. The lubrication engineer will make an exhaustive analysis of the operating functions of the engine and thus will be able to intelligently advise the kind of lubricants best suited to the engine's requirements.

In the case of a diesel engine that is in good operating condition but which is displaying symptoms of trouble or of approaching operation difficulties, a good lubrication engineer should be called in before the engine has had time to develop serious troubles. He will then be able to diagnose the prevailing conditions and make recommendations for curing the trouble.

This procedure should be followed whenever any unfavorable operational conditions are observed. In some instances it may require experimentation with various types of lubricants before one will be proven the best type to cope with a particular probblem or condition. Due to the complexity of diesel engine lubrication requirements, one should not become discouraged at failure to achieve quick results in overcoming a particular problem. Sufficient time should be allowed for a thorough study and analysis so that the root of the trouble may be found and any contributory conditions located at the same time.

What Are the Lubrication Problems

While it is important to avail oneself of the services of expert lubrication technicians in deciding the types of lubricants best suited for a diesel engine, it is also important that the operator have a clear understanding of the lubrication problems of such an engine, and that he have a sufficient knowledge of symptoms to diagnose unsatisfactory operating conditions before trouble occurs.

Internal combustion engines are sensitive to excessive wear of pistons, piston rings and cylinder liners. The piston rings are made of softer metal than the cylinder liners in order to concentrate wear on the less costly rings. However, cylinder wear of approximately four thousandths of an inch per thousand hours of operation is usually considered normal.

Symptoms of excessive cylinder wear include smoky exhaust, accompanied by an acrid odor. This condition is usually accompanied by high consumption of fuel and lubricating oil, and may also involve loss of power. However, a faulty exhaust may also indicate trouble. Other symptoms of excessive cylinder and piston wear may be audible blow-by, crankcase dilution and noisy operation.

Piston rings must have constant motion, both vertically and horizontally, within the piston ring groove. If excessive cylinder wear occurs during engine operation, the minute metal particles that are rubbed off will form a binder that, when mixed with carbon from unburned fuel and partially burned lubricating oil, will produce a sticky deposit which will cause piston ring sticking.

If the fuel injector is worn, distorted or clogged, this also may have a detrimental effect on the piston rings. A worn injector may permit leakage of fuel into the cylinder, thus causing improper combustion or washing away of the lubricating film from the cylinder wall. Cylinder wash can result in ring sticking.

If the injector fails to seat properly, small drops of fuel oil adhering to the injector nozzle may only partially burn and cause carbonization of the injector nozzle, thus resulting in smoky exhaust.

Tests show that one faulty injector out of six can put 25 per cent more soot into the lubricating oil than can all six injectors togethers when working properly.

Injectors should be replaced when they have reached the end of their usefulness to prevent injector failure and possible detrimental results. Excessive injector wear may be caused by grit or dirt in the fuel oil. To eliminate such difficulties it is important to keep fuel oil clean while in storage, and to maintain the fuel oil filters in good operating condition.

Bearing Materials

Due to improved bearing materials and designs, the problem of bearing failure is relatively slight. However, clogging of lubricant passages and lines can prevent lubrication of bearings and result in their damage or destruction and must be guarded against.

The contamination of the lubricating oil from inside and outside causes can have detrimental effects on the engine. Inside contaminants include carbon, water, dilution, acids and metallic particles. Outside contaminants include dust, dirt and other foreign material.

The causes and effects of oil contamination form a circle of events that renders diagnosis sometimes difficult. For instance, where excessive carbon has caused stuck rings, if the carbon is formed first, it may be deposited behind piston rings and work its way into the lubricating oil. When the oil is subjected to high temperatures and the oxidizing effect of the air, sludge is formed. This will accelerate ring sticking and this may result in scored cylinders.

If, on the other hand, cylinder scoring occurred first, excessive blow-by would follow. This would form excessive carbon around the rings, due to excessive heat, thus causing ring sticking.

In this way, any one of the inside contaminants formed in used lubricating oils may start this circle of troubles, and once started, it usually leads to complete engine failure unless noted and corrected by the operator.

Formation of Sludge

Low temperature sludge forms mostly in engines in which water and other contaminants are present in the crankcase oil. Such sludge can build

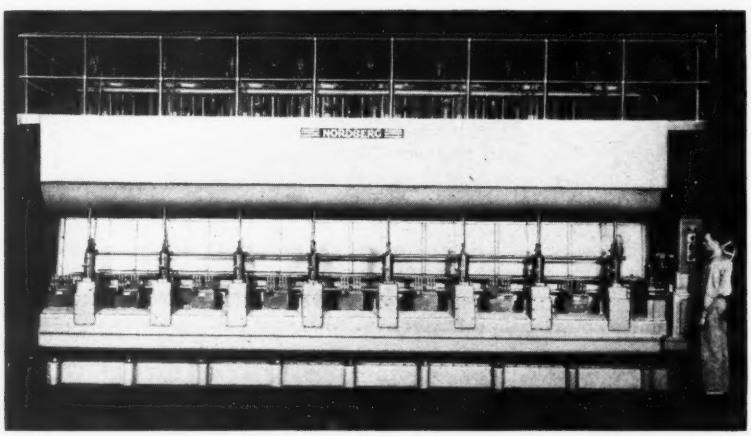

Fig. 2. An 8-cylinder, 3200 bhp Nordberg diesel engine using a motor-driven scavenging blower

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up to a considerable depth on the crankcase sidewalls, inside oil coolers, or on any other engine surface exposed to moderate or low atmospheric temperatures.

In order to minimize low temperature sludge it is important that the jacket water temperature be at least 75 F when the engine is started. It is also desirable to warm up the engine before putting a load on it.

High temperature sludge differs from low temperature sludge in that it is composed of crankcase oil thickened with oxidation and thermal decomposition products. The oil will contain carbon, resulting from incomplete combustion of both fuel and lubricating oil in the combustion chamber. This carbon has reached the crankcase through the action of the piston rings or by blow-by, or both.

The oxidation and thermal decomposition products in the crankcase oil may appear as fine solids difficult to filter out, or as small granules resembling coffee grounds.

The theory is held in some quarters that most of such granules are formed as a result of adding fresh oil, low in solvent power, to oxidized oil, either as make-up oil or when the crankcase oil is changed. It is believed that the addition of fresh oil to the used oil, even the quantity that usually remains in the engine after draining the system, will form sludges if the used oil is oxidized. These sludges then change into the hard granules on being exposed to further heating. These granules might on occasion plug the crankshaft oil passages or the oil lines and oil screens, either of which can cause bearing failure.

Effect of Dust

In order to minimize the quantity of dust that reaches the interior of the engine, proper precautions should be taken to filter out as much of this dust as is possible. Dust is very detrimental to any type of diesel engine, but is even more damaging to two-cycle engines than to the four-cycle type.

In engines where ring sticking or "varnish" is a problem, special lubricating oils, known as "heavy duty" oils, have been used with some degree of success for power cylinder lubrication. These oils usually prove detrimental, though, if used as a crankcase lubricant in large stationary engines. However, where oil temperatures in engines run abnormally high (190 F and over), such oils have been employed as crankcase lubricants by operators fully acquainted with their advantages and disadvantages in such applications.

"Heavy duty" oils are oils containing special chemicals called additives. These chemicals are intended to improve the oxidation resistance of the oil and give it special cleansing qualities.

Too much reliance should not be placed on the oil conditioning equipment of large diesel engines. These are excellent for their purpose, but it will prove more profitable if the oil be checked at set intervals of about three months of operation. This work should be entrusted to a competent laboratory to determine the presence of oxidation products, solids, water, fuel, etc. In this way, it can be ascertained when the oil becomes unfit for further use under the prevailing operating conditions.

On diesel engines employing air injection compressors, specially compounded oils for air compressor lubrication should be used to lubricate the compressors. Such oils must have high oxidation resistance and leave a minimum of carbon deposit. The reason for this is that usually some of the water that condenses from the air between compression stages is picked up by the air and carried into one or another of the compressor cylinders following intercooling. This water has an adverse effect on lubrication and can also cause rusting of the valves, cylinders, piston rings, pistons, etc.

Effect of Excessive Clearance

Excessive clearances in the main, connecting rod and camshaft bearings is a major cause of high oil consumption in an engine with pressure lubrication. These bearing clearances serve as metering devices to control oil flow and provide balanced lubrication for the entire engine. If the bearings pass too much oil, an excessive amount may reach the cylinder walls. There, despite the efforts of the piston rings, the oil is likely to reach the combustion chamber where it dilutes the combustible charge, causes carbon deposit and produces smoke.

It should be remembered that correct oil pressure does not always indicate a satisfactory bearing condition throughout the engine.

It is highly important that all parts of the lubrication system of an engine function properly. This means that the oil pump or pumps must do their work satisfactorily in order to insure an adequate supply of oil at all times while the engine is running. The filters, coolers and any other oil conditioning equipment must keep the lubricant in good clean condition. And any auxiliary oil feeding devices must be reliable and kept properly adjusted so that they will furnish exactly the proper quantity of lubricant required for each application. Failure to maintain the lubrication system in satisfactory operating condition may result in serious bearing or other damage.

Often certain clues are helpful in pointing to the cause of lubrication difficulties. Carbon deposits form most rapidly in the combustion chamber and on the under side of the piston heads. From these locations it flakes off and finds its way into the lubricating oil, thus helping to speed up the formation of sludge.

Water produced by combustion and condensation, when present in excessive quantities, will be indicated by the rapid formation of sludge.

Thinning of the lubricant, accompanied by high consumption of the lubricating oil, indicates fuel dilution. If this condition is not immediately remedied, loss of engine power and mechanical damage will result.

If highly polished engine parts show corrosion, it is an indication of the presence of acid formation in dangerous quantities. This condition is generally caused by a combustion of water with the acidic content of partially burned fuel.

Excessive quantities of metallic particles found in the lubricating oil indicate rapid wear of pistons, rings, cylinders and bearings. Such metallic particles contribute to excessive abrasive wear and sludge formation.

Sludge is the most dangerous enemy of the engine. It will jam piston rings, clog injectors, accelerate carbon formation, and restrict or even close oil lines, thus leading ultimately to lubricating system failure and hence the engine.

Loss of power, high fuel and lubricant consumption, injector clogging, noisy operation, and smoky exhaust indicate piston ring sticking. Such a condition rapidly increases cylinder wear and, if neglected, will finally result in serious damage.

By checking compression pressures it is possible to detect excessive cylinder wear. Where an excessive amount of fuel is present in the combustion chamber, cylinder wear will increase rapidly.

Excessive engine vibration, uneven firing and smoky exhaust point to injector clogging. Injector clogging may also be indicated by a sudden rise in the exhaust temperature, as recorded by a pyrometer.

A knocking noise will warn of excessive bearing wear. As the wear increases the noise will grow louder. Low oil pump pressure is an indication to the operator of this condition, providing the lubricating oil is of the proper viscosity. Such a warning should be heeded immediately because it may lead to a bearing failure, resulting in a broken connecting rod or crankshaft. Such an occurrence will totally wreck a running engine.

The remarkable efficiency of the diesel engine (35 per cent as compared with 25 per cent for the gasoline engine and 10 per cent for the steam engine) can only be retained by proper operation, care and maintenance. Any neglect of these matters will result in loss of efficiency and needless wear, very costly items in the case of a large engine. Since faulty lubrication can be a major cause of excessive engine wear, it is extremely important that every effort be made to insure proper and adequate lubrication. And any question that perplexes the operator of a diesel concerning lubrication should be immediately referred to a diesel lubrication engineer.

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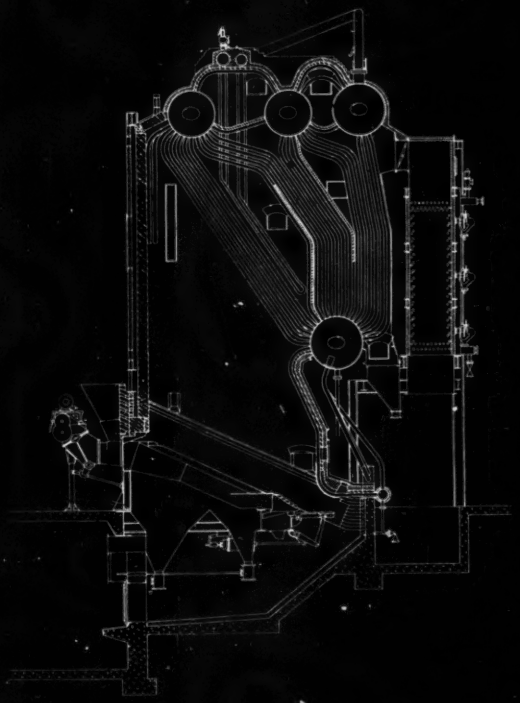

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Aspirin Cures ONE Water Testing Headache

By R. S. WISE and R. S. ROBERTSON
National Aluminate Corporation

Aspirin tablets have been found to be an excellent substitute for the strong acid reagents now used in the electrical conductivity method for dissolved solids testing of boiler feedwater. Aspirin is actually a very weak organic acid, in tablet form, with each tablet containing a convenient amount of acid; thus eliminating the danger involved in handling strong acid solutions or the necessity of accurately measuring a powdered material

THE ELECTRICAL conductivity method of measuring the amount of dissolved solids present in boiler water assumes that all constituents have approximately equal specific conductances. To make this assumption valid, the sodium hydroxide and sodium carbonate normally present in the boiler water must be converted to salts having conductances similar to the other components. The usual standard procedure employs a solution of strong sulphuric acid for this purpose. Unavoidably, some accidents may occur in the handling of this strong acid. For this reason alone analytical procedures for plant testing work avoid the inclusion of strong acid reagents wherever possible. The sulphuric acid procedure gives accurate results only when exactly the required amount of acid is used in the boiler water sample. Because errors of large magnitude may be introduced merely by adding too little or too much sulphuric acid, a method requiring less skillful technique would be desirable. In fact, the addition of a constant amount of a harmless reagent would greatly simplify the complete test procedure for the measurement of dissolved solids.

It has been proposed that any one of several weak organic acids might be used to good advantage in place of sulphuric acid[1]. These weak organic acids have extremely low specific conductances and therefore would not introduce an error into the dissolved solids reading even though they were added in excess to every sample. One particular weak organic acid, gallic acid, has been proposed as a substitute for sulphuric acid[2]. The addition of an excess of gallic acid or one of the other weak organic acids suitable for this purpose eliminates the need for exact neutralization of the sample in making the dissolved solids test. Most of the weak organic acids that would be suitable for this purpose exist as powder or crystals of limited solubility in water. The use of these materials in powder form necessitates some measuring device which may or may not be sufficiently accurate for the purpose. In addition, the stability of a number of weak organic acids may be questionable, some of them being subject to oxidation or other chemical reaction. Since the weak organic acids are not widely used as chemical reagents, some difficulty may be experienced in obtaining the powdered or crystalline material at all. Also the required material may not be readily available in the desired purity.

[1] Private Communication, Industrial Instruments, Inc., June, 1946.
[2] Combustion, May, 1945, page 35.

Aspirin—A Weak Acid in Tablet Form

If it were possible to use a weak organic acid in tablet form, with each tablet containing a convenient amount of acid, this would eliminate the necessity of handling and measuring a powdered material. If such a tablet, in addition, had known stability, purity, and availability characteristics, it would make this tablet even better for application to the dissolved solids test. Aspirin tablets meet these requirements exactly. Ordinarily we do not think of aspirin or acetylsalicylic acid in the light of its acidic nature. Actually this material is a very weak organic acid. Aspirin or acetylsalicylic acid tablets have been tested thoroughly in our laboratory and have been found admirably suited for use in this analytical procedure.

A number of different brands of one grain and five grain tablets have been tested and most of the various brands give satisfactory results for this purpose. Of course, no pharmaceutical tests were made on the tablets. For our purposes, all of the standard brands exhibited high purity and uniformity. Five grain tablets marketed by Sterling (Bayer), Medical Supply, Reed Products, Squibb, Stineway, and Plough (St. Joseph) were all found to give good results. One grain tablets marketed by Eli Lilly, Parke Davis, and Upjohn all showed the desired characteristics for this test.

Conductivity Measurement

Several different types of electrical conductivity measuring instruments are available for dissolved solids testing of boiler water. Some of these instruments give the conductivity readings expressed in microhms, and the results thus expressed are converted to grains per gallon or parts per million by application of an arithmetic conversion factor. The instrument used in this investigation is a Nalcometer of a bridge circuit type. This instrument also measures conductivity, but gives readings direct in grains per gallon or parts per million without the need for a conversion factor. Direct reading instruments of this type calibrated for the sulphuric acid procedure would require recalibration for any weak acid procedure. The sodium salt of any of these weak organic acids has a lower specific conductance than sodium sulphate. Consequently, substituting gallic acid or aspirin for the sulphuric acid would give low dissolved solids readings on an instrument calibrated for use with the sulphuric acid procedure. For maximum accuracy in the dissolved solids test, a direct reading instrument such as a Nalcometer should be recalibrated on the basis of gravimetric dissolved solids determination on a sample of boiler water from the particular plant in which the instrument is used.

The exact analytical procedure best suited for aspirin neutralization of the boiler water sample prior to conductivity test depends somewhat upon the size of sample normally used and the range of boiler water alkalinity encountered. As shown in the graph

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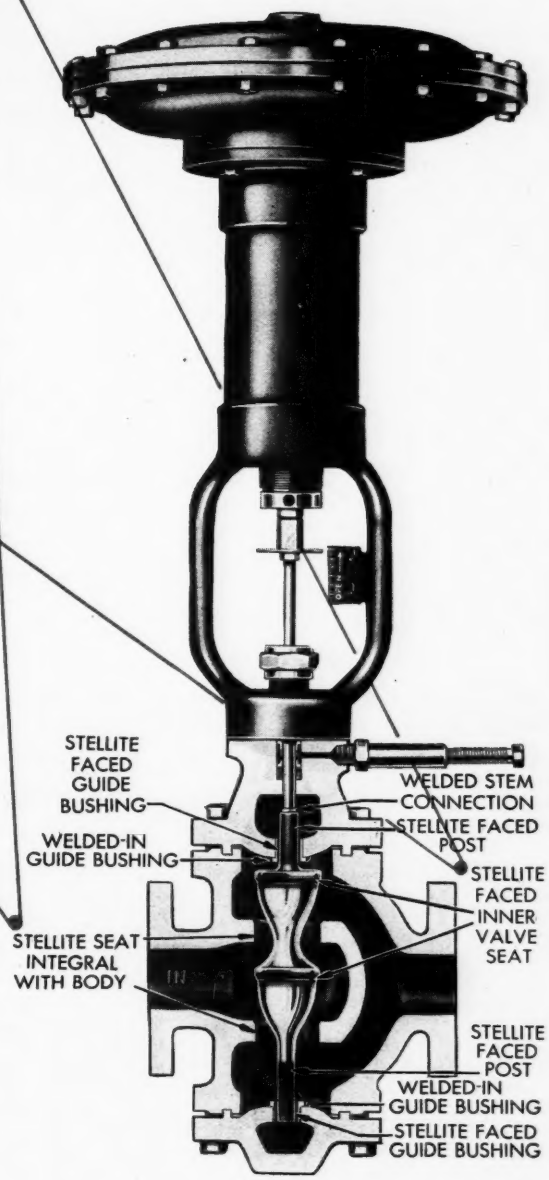

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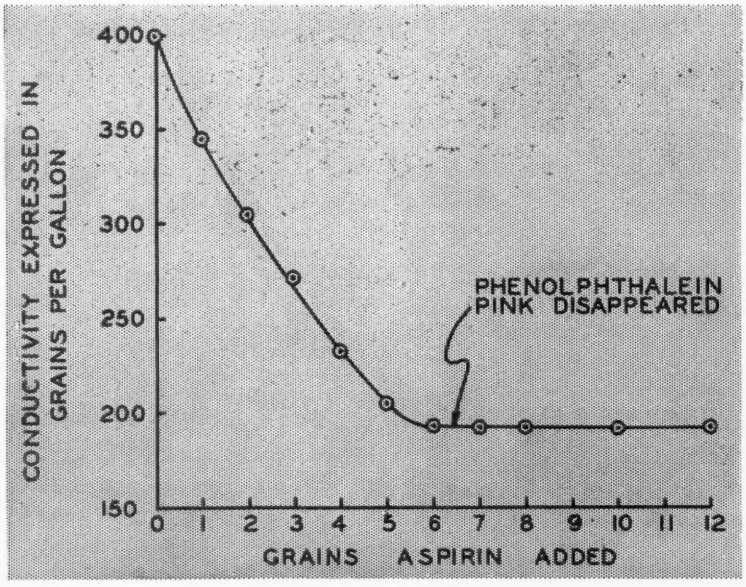


Graph showing the relation between conductivity reading and grains of aspirin added for boiler water sample of unusually high alkalinity

below, a boiler water of unusually high alkalinity was tested with the addition of increasing amounts of aspirin tablets. The conductivity reading expressed as grains per gallon dissolved solids was found to be 400 grains per gallon with no neutralization. When aspirin had been added in sufficient quantities to convert all of the sodium hydroxide and sodium carbonate into salts of lower specific conductances, the dissolved solids reading, 185.0 grains per gallon, remained constant even with considerable excess aspirin present. The sample used in this case was 90 ml. This example illustrates that for this size sample, a single five grain tablet would be adequate if the sample did not contain more than 60 grains per gallon (1,000 parts per million) phenolphthalein alkalinity.

Testing Procedures

Two alternate procedures are suggested using aspirin or acetylsalicylic acid tablets. The first procedure is for large samples with high alkalinity; the second for smaller samples or lower alkalinity.

Procedure No. 1: Size sample—60 to 100 ml. with phenolphthalein alkalinity between 15 and 60 grains per gallon (255 to 1,000 ppm).

(A) Add two drops phenolphthalein indicator to sample.

(B) Add one five grain tablet to the sample.

(C) Take reading with Nalcometer or other electrical conductivity instrument after three minutes or after phenolphthalein pink color disappears.

Procedure No. 2. Size sample—30 ml. to 60 ml. with greater than 15.0 grains per gallon phenolphthalein alkalinity; size sample—60 to 100 ml. with phenolphthalein alkalinity less than 15 grains per gallon (255 parts per million).

(A) Add two drops phenolphthalein indicator to the sample.

(B) Add two one grain tablets to the sample.

(C) Take reading with Nalcometer or other electrical conductivity instrument after three minutes or after phenolphthalein pink color disappears.

Operating Data on a Dual-Fuel Diesel

Method of operation and data on operating economies of a dual-fuel Diesel in the oil fields is given in this recently-released report . . . Step-by-step starting and operation of the engine is explained

TWO INDEPENDENT developments in the design of Diesel engines have widened the application of this engine. Combined in one engine recently by The National Supply Company, Superior Engine Division, both turbo-supercharging and dual-fuel operation have now been applied successfully.

Dual-fuel engines, a number of which have been operated in Texas and Wyoming permit a long needed flexibility of engine operation on either oil or gas. These engines are convertible from one fuel to the other by the movement of a single lever while the engine is running. Their use avoids the common practices of (1) stocking two engines for the same service or (2) of moving and storing conversion accessories, which require considerable time and labor to convert Diesel engine to a spark-ignition gas engine or the reverse, when fuel conditions require.

An important advantage of this dual-fuel engine design is that the necessary accessories can be added at any time to this company's Diesels already in service. They add about 10 per cent to the cost of new engines and the weight added is negligible.

Supercharging increases the power output of a Diesel engine as much as 60 per cent or more with only about 15 per cent increase in weight. The

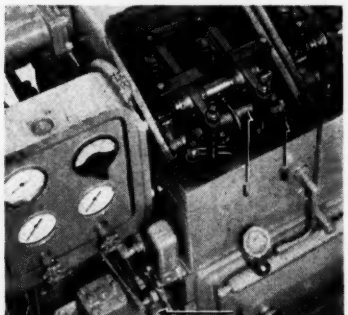
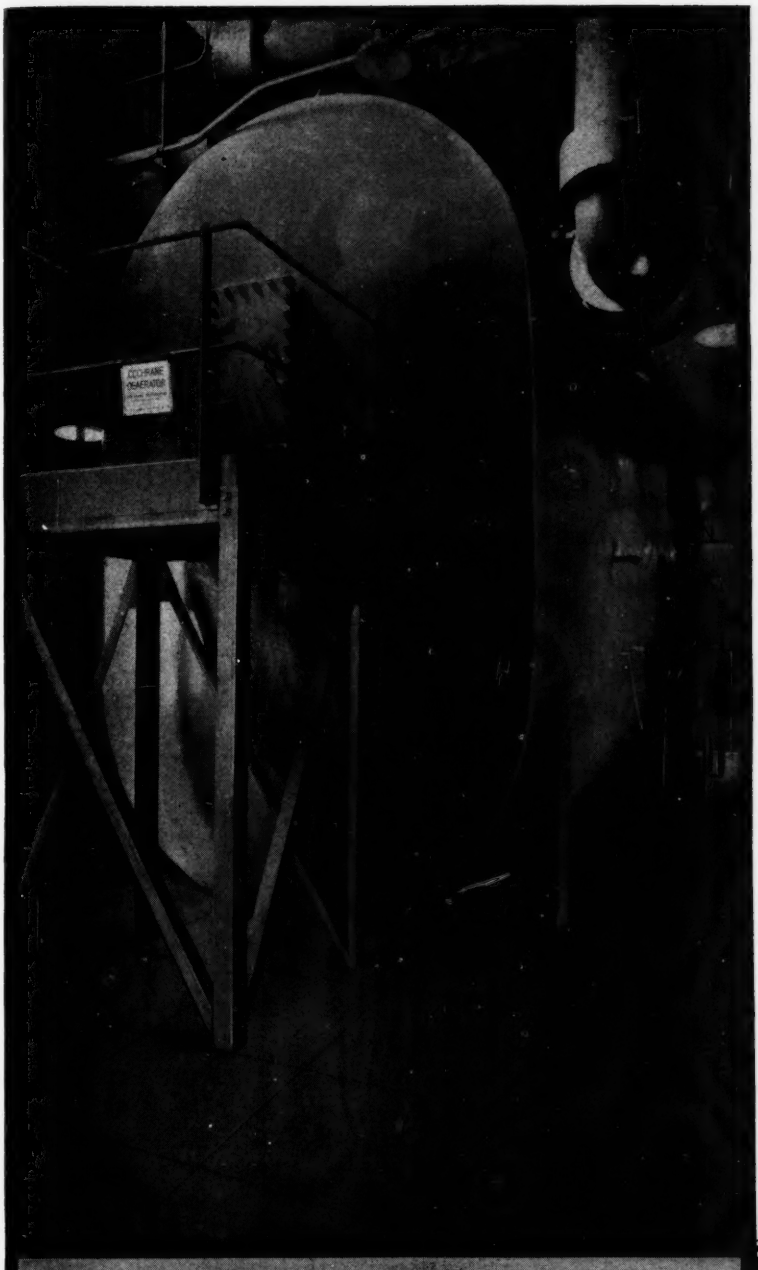


Fig. 1. Controls and rocker assemblies of the PTDS-8 supercharged dual-fuel engine, showing starting air valve (B), control lever (C), eccentric bushed rocker (L), and its actuating hydraulic cylinder (M)



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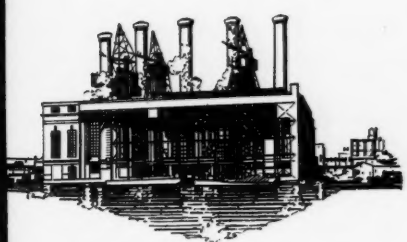

AT Consolidated Edison's Hell Gate Station in New York, large capacity equipment was required for the deaeration of returned condensate, but space limitations would not permit conventional deaerator design. To Cochrane engineers, however, this was no unusual problem. Their solution was the elliptical rolled plate deaerator, shown above. Its capacity is nearly two million pounds per hour.

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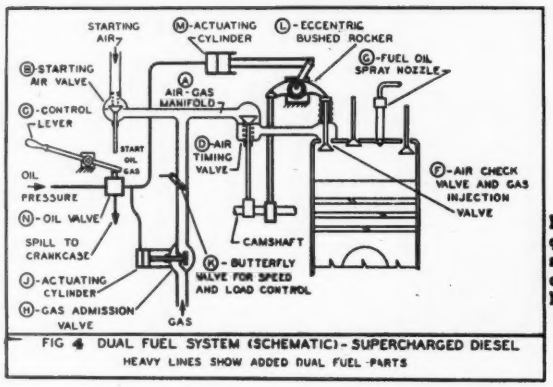

FIG 4 DUAL FUEL SYSTEM (SCHEMATIC) - SUPERCHARGED DIESEL
HEAVY LINES SHOW ADDED DUAL FUEL PARTS

Fig. 2. Schematic diagram of the dual-fuel system in a supercharged Diesel. The heavier lines show the added dual-fuel parts

weight per horsepower is reduced 40 per cent.

Field tests of a turbo-supercharged, dual-fuel engine drilling in a California oil field demonstrated the flexibility and fast getaway of the engine under actual drilling conditions. The engine responded quickly to the throttle with either heavy load or empty blocks, the turbo-charger introducing no lag in rig performance. Anticipated fuel economies of dual-fuel operation were shown, exceeding at full load the well known high efficiency of the straight Diesel engine.

Supercharging increased engine power with only slight increase in cylinder pressure and negligible increases in crankshaft and connecting rod bearing pressures. This is because higher average pressure is maintained during the power stroke. Little more cooling capacity is required because considerable heat is dissipated by the scavenging air.

Superior engines are supercharged by the Elliott-Buchi turbocharger, which consists of a gas turbine operated by engine exhaust gas on its way to the atmosphere and has no connection with the engine crankshaft. A blower on the same shaft with the turbine supplies scavenging and combustion air to engine cylinders at a pressure greater than that of the atmosphere. Speed and output of the turbocharger vary automatically with engine speed and load, or both, making control equipment unnecessary.

In Dr. Diesel's original patents the burning of liquid, gaseous and even solid fuels on the more efficient high compression cycle was considered. The dual-fuel engine was developed in Europe several years ago when liquid fuels became scarce and combustible by-products gases were available. Variable availability and fluctuating prices of fuels have influenced the development of dual-fuel engines in the United States.

It has been demonstrated that gas alone does not ignite regularly at the compression pressures and corresponding ignition temperatures in conventional Diesel engines. Consequently in gas operation it is necessary to burn also a small proportion of oil as a pilot fuel for igniting the gas.

A fixed quantity of pilot oil, equivalent to 10 to 15 per cent of the full load oil consumption, must be used under the conditions of intermittent operation of drilling engines, although lesser amounts can be used under laboratory conditions of operation. The actual ratio of gas to oil varies with engine load. Thus gas consumption may vary from a few per cent at idling loads to about 87 per cent of the total fuel at full load.

The problem of introducing gaseous fuel into a supercharged dual-fuel engine, created by scavenging at the end of the exhaust stroke, was solved by a novel gas-injection system. In this system, shown diagrammatically in Fig. 2, the starting air check valve for dual-fuel engine operation is used for injection of gaseous fuel. This makes the heads of straight diesel and dual-fuel engines interchangeable.

To start the engine the control lever (C) in Fig. 2 is thrown to starting position. This admits starting air under pressure to the manifold (A). While the engine is starting the gas valve (H) is closed and the hydraulically actuated eccentric bushing (L) disengages cam control of the air check valve (F), allowing it to act simply as a spring loaded check valve. High air pressure forces the air timing valve (D) down against the cam shaft to time admission of starting air to the cylinder.

After the engine is started, the control lever (C) is moved to an intermediate position which prevents both starting air and gas from entering the manifold, and the engine operates on oil.

If dual-fuel operation is desired, the control lever (C) is moved farther to open oil valve (N) which actuates the hydraulic cylinders (J and M) on gas admission valve (H) and eccentric bushing (L). Gas is then admitted to the starting air manifold where it is controlled by butterfly (K) and injection valve (F). The air timing valve (D) remains open because the gas pressure is not sufficient to force it down on the cam against its spring.

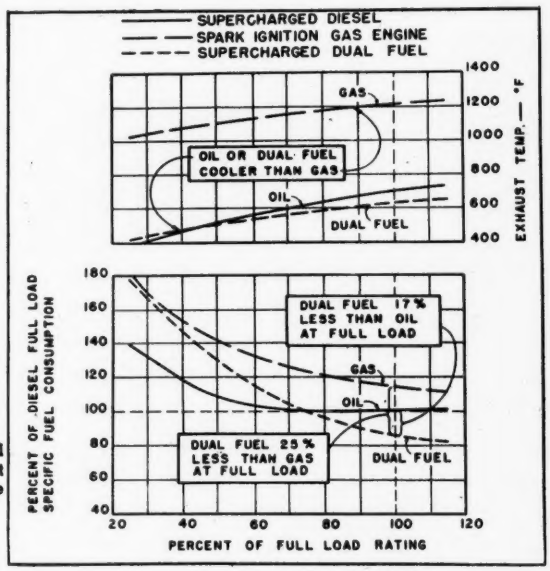

Fig. 3. Comparative fuel consumption and exhaust temperatures of three types of engines

The fuel consumption of the supercharged dual-fuel engine as compared with the straight supercharged Diesel and conventional spark-ignition gas engine is shown graphically in Fig. 3.

The dual-fuel engine is even more economical than the straight diesel at loads greater than 75 per cent of full load, and at full load this saving amounts to about 17 per cent. It is interesting from a technical point of view that the relatively high percentage of pilot oil results in better economy than when minimum pilot fuel is used under controlled conditions. The comparison of exhaust temperatures in Fig. 3 is also significant.

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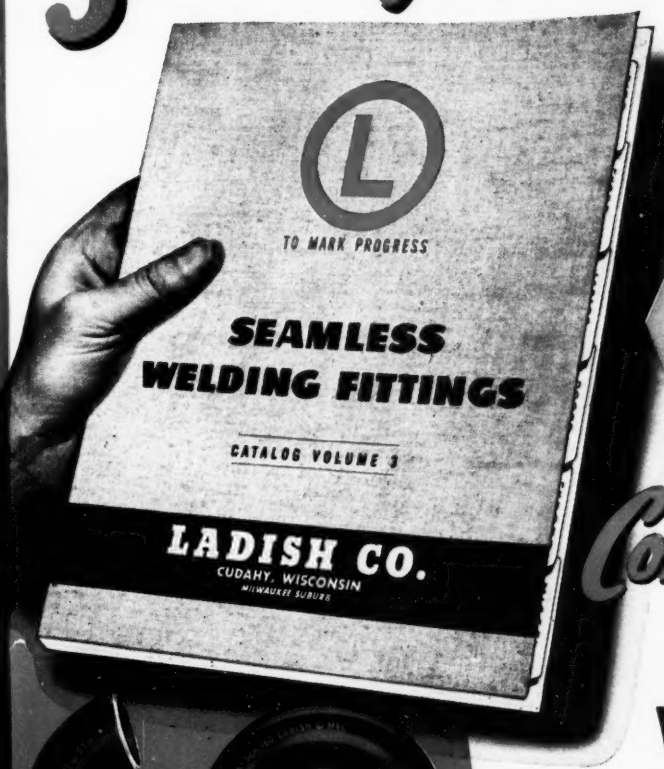

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National Fuels Conference

Tenth of joint conferences held annually by committees of the ASME and AIME . . . Cincinnati meeting October 20 and 21 featured coal mining and preparation problems, underground gasification, air pollution, and a symposium on operation of small coal-fired boiler plants

UNDER the joint sponsorship of the Fuels Division of the American Society of Mechanical Engineers and the Coal Division of the American Institute of Mining and Metallurgical Engineers, the 10th National Fuels Conference was held in Cincinnati, Ohio, October 20 and 21.

In the paper entitled "Stability of the Atmosphere and Its Influence on Air Pollution" by Henry F. Hebley who has investigated the sources of atmospheric pollution, principally in the city of Pittsburgh and vicinity, pointed to some of the influences that are exerted on this problem of atmospheric pollution, stating that the industrial area of Pittsburgh, Pa., has been a dominant center for the production of iron and steel for over 100 years. In addition the type of manufacture carried out in this area is predominantly dependent on thermal energy—heat. That energy is supplied from coke and coal produced in the vicinity of Pittsburgh. No matter what adventures the gases of combustion experience as they pass through the various processes, ultimately the spent gases are discharged through chimneys to the atmosphere. Forming a portion of those gases of combustion are quantities of the oxides of sulphur and nitrogen, both of which incidentally are colorless gases.

The very advantages which the Pittsburgh area offers to industry are accompanied by difficulties of topography associated with the steep valleys of the Allegheny, the Monongahela, the Youghiogheny and the Ohio Rivers. These are natural conditions and create local climatic situations affecting air pollution that bear earnest consideration. Such conditions have been augmented by human activities through the location of rail and water transportation, practically at the river level, together with the concentration of industry within the confines of the narrow steep valleys. It will be noted that the steep valleys around Pittsburgh form convenient conduits through which the atmospheric pollution may flow by air drainage from the numerous industrial centers situated in this Ohio River drainage area.

In such broken terrain with steep hills and valleys running in many directions, local air movements in the lower layers are extremely complex. At the higher levels there are for the most part wind movements with a westerly component. These great westerly air movements are very steady. However, under such local interference of terrain the disturbing influences are very great when compared to those encountered in the cities of the plains.

Superimposed on these local fluctuations are the steady air flows down the tributary valleys into the main valleys of the Monongahela, Allegheny and Ohio Rivers. This condition is known as the air drainage system and, provided weather conditions are conducive, cooled air will flow into the system from as far afield as Morgantown, W. Va., on the Monongahela, New Kensington on the Allegheny or New Castle on the Beaver River.

In any study of the problem of atmospheric pollution, Mr. Hebley contends, the influences of the turbulence and stability of the air are of paramount importance. These conditions are related to the general air drainage movement; but some of the local factors and terrain exert effects that greatly modify the final results.

The whole question of atmospheric pollution and condition of moisture in the natural atmosphere was discussed in detail and the author came to the conclusion that there can exist a daily cycle of air conditions over a highly industrialized area in which topography, locations and seasons combine to create polluted atmospheric conditions, provided large scale weather phenomena favor it.

In the paper by Hans Neuberger of the Pennsylvania State College, entitled "Sifinificance of Condensation Nuclei in Atmospheric Pollution," it was pointed out that the properties of two types of aerosol, namely dust and condensation nuclei, figure prominently in the problem of air pollution. Predominance of natural in contrast to man-made sources of atmospheric pollution in general, and the physical effect of nuclei in particular, indicates that the suspensions are an integral part of the atmosphere. The relative importance of dust and nuclei with respect to concentration, distribution, persistence, physico-chemical and biological effects was weighed by the author. He discussed in scientific terms such topics as the atmospheric constitutents, dust, condensation, nuclei, the chemical nature of condensation nuclei, the source of nuclei, the physical properties of nuclei, comparison between the two types of aerosol, and in conclusion stated that in general this field offers as yet untouched opportunities for the physiologist, physician, bacteriologist, epidemiologist, physicist, chemist, meteorologist, and engineer to combine their knowledge and skill in fundamental research on the biological effects of atmospheric pollution.

One of the interesting features of the meeting was the presentation of a paper on Underground Gasification at Gorgas, Ala., prepared by M. H. Fies, consulting engineer and manager of coal operations for the Alabama Power Co., and W. C. Schroeder, chief of the office of synthetic liquid fuels of the U. S. Bureau of Mines. This paper discussed the history of this experiment in the gasification of fuel underground, described the methods used for the selection and preparation of the site and the operation procedure. It gave the results of their examination after the experiment had been concluded and the following conclusions were drawn from this first preliminary experiment: Combustion can be maintained without difficulty and in a passage of about 300 ft, or considerably less, practically all oxygen is consumed. This indicates turbulence in the gas stream which brings all parts of it into contact with the combustible material. Coking precedes actual combustion and produces a coke bed that should be very satisfactory for producer or water gas operation providing the oxygen and steam can be forced through this bed.

This experiment, the authors believe, shows that coal can be burned and gasified completely underground with little or no loss of combustible material.

In this experiment it is doubtful if high enough temperatures or a sufficient area of high temperatures were obtained to secure gas of maximum heat content.

The roof will fall (in this case) following combustion of the coke. This does not stop the flow of air or combustion but it does increase the back pressure on the blower.

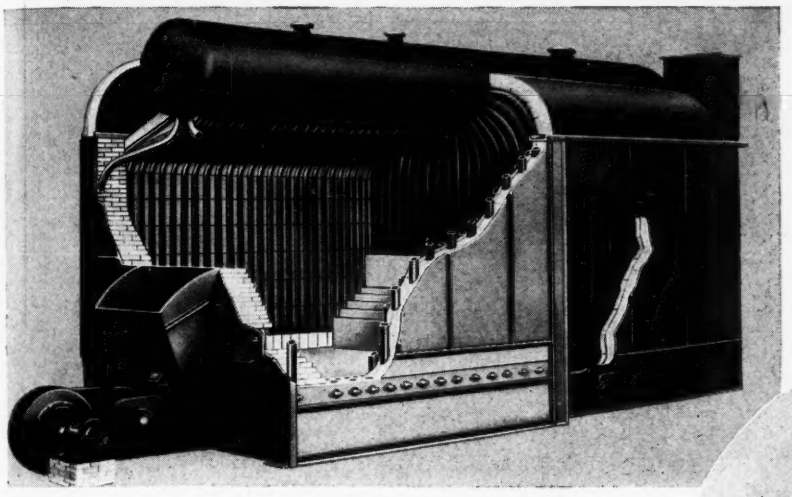
In regard to future experimentation, it was stated that in future experimentation it is evident that difficulties such as encountered here can be prevented by working under much deeper cover and far enough from the outcrop to eliminate all possible leaks. The necessary distances can now be predicted quite accurately from this first underground work. To secure high flow of air and increased temperature the blower should have considerably increased capacity and should be capable of operation up to about 2 or 3 atmospheres pressure.

Small Power Plants

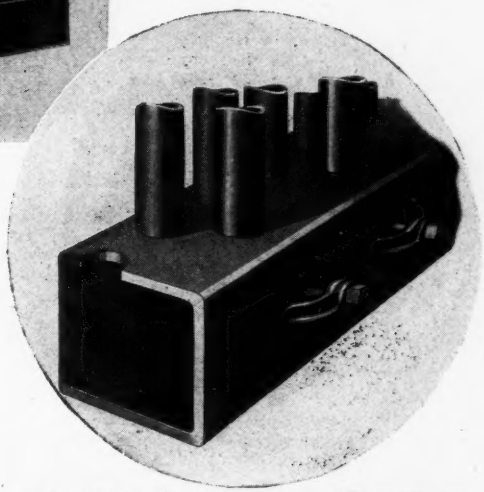
The careful operation of small power plants during the last war period resulted in bringing about improved technique both as to burner and boiler operation, as well as to fuel purchasing and planning, said C. A. Reed in his discussion of the problem, The Relation of Fuel to Proper Equipment Operation. A wider variety of coals—both as to size and quality, is now known to be economically useful. Novel equipment had to be built

(Continued on page 124)

TYPE-VL *A Low Headroom*
2-DRUM WATER WALL BOILER



SHIPPED BUILT-UP IN SIZES TO 300 H. P.



Water Wall tube arrangement—1 Downcomer for each 2 Riser Tubes

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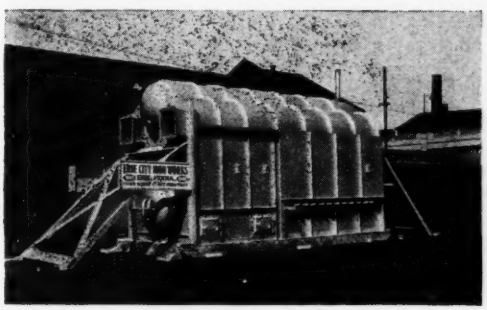

Shop assembled and shipped as a unit in sizes to 300 H. P.

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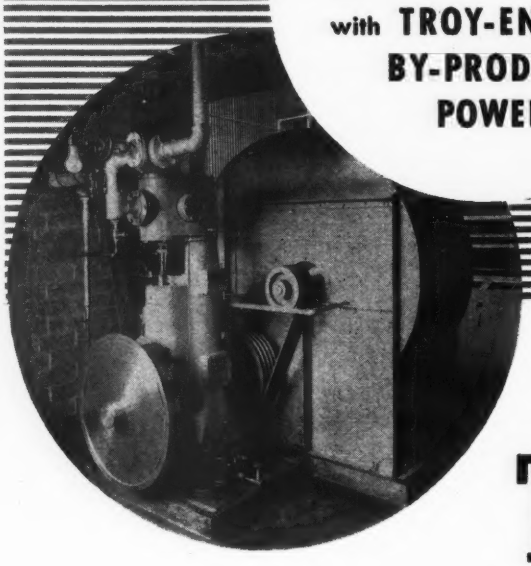

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STEAM ENGINES • GENERATING SETS • GENERATORS

NATIONAL FUELS CONFERENCE

(Continued from page 122)

during the war years and its performance indicates a marked trend in the adaptability of burners for a wide variety of operating conditions.

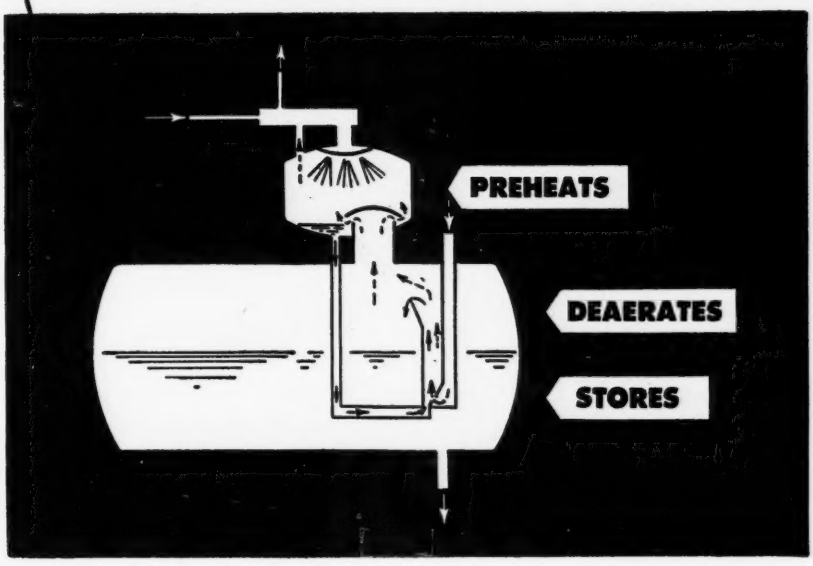
"In view of the subsequent national drive in urban areas for the elimination of air pollution, such drives, whether enforced by law or accomplished by cooperative effort, will make for better boiler setting conditions, and purchase of a certain amount of automatic control, and a better understanding of their equipment and fuel by firemen and engineers in these small plants. One of the greatest helps that can be given at this point is to educate, through the equipment sales and fuel people, the real merits of purchasing properly and saving the difference over a period of years by being able to maintain higher efficiency, having lower maintenance costs, and having equipment to use a wider range of fuels."

Mr. Reed emphasized that in the class of plants requiring from 2000 to 10,000 tons of coal per year, the engineer or fireman of such plants usually has other duties to perform, and, therefore, a minimum of auxiliary automatic equipment should be recommended, with actual facts to prove the possibility of a return on the investment. Inexpensive coal handling is also available, and this may reduce not only labor cost, but may also minimize segregation, which is a bugaboo on small equipment.

"Design and Operation of Small Coal-Fired Boiler Plants" was the title of a discussion presented by P. F. White and C. F. Golding, Senior Engineers of the Anthracite Institute, in which they pointed out that the use of automatic anthracite stokers to burn small sizes of anthracite within the range of 3000 to 20,000 lb of steam per hour has been increasing in this large and undeveloped field. It is anticipated that the use of anthracite in this range will continue to increase with additional equipment development; and the industry is preparing for such a demand in its program of upgrading of sizes. As a result of anti-stream pollution legislation recently put into effect, the Anthracite Institute has engaged in a research program to pelletize silt taken from breaker wash water. The pellets have been experimentally fired at various colliery boiler plants in order to fix on a method of profitably disposing of the silt in this form, in order that more of the standard colliery fuel, usually Buckwheat No. 2, No. 3 and No. 4 may be replaced for commercial consumption.

The authors pointed to the importance and size of this problem, noting that a five year average consumption of colliery fuel is 2,217,680 tons or 3.78 per cent of the total anthracite production. A great amount of statistical material was presented on anthracite production, particularly in

STOP BOILER CORROSION



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And here are some additional design advantages... no moving mechanism ... no trays to corrode or get fouled ... countercurrent flow of steam and water for greatest efficiency. Write for Bulletin 2 describing the LIQUON Deaerating Heater in greater detail.

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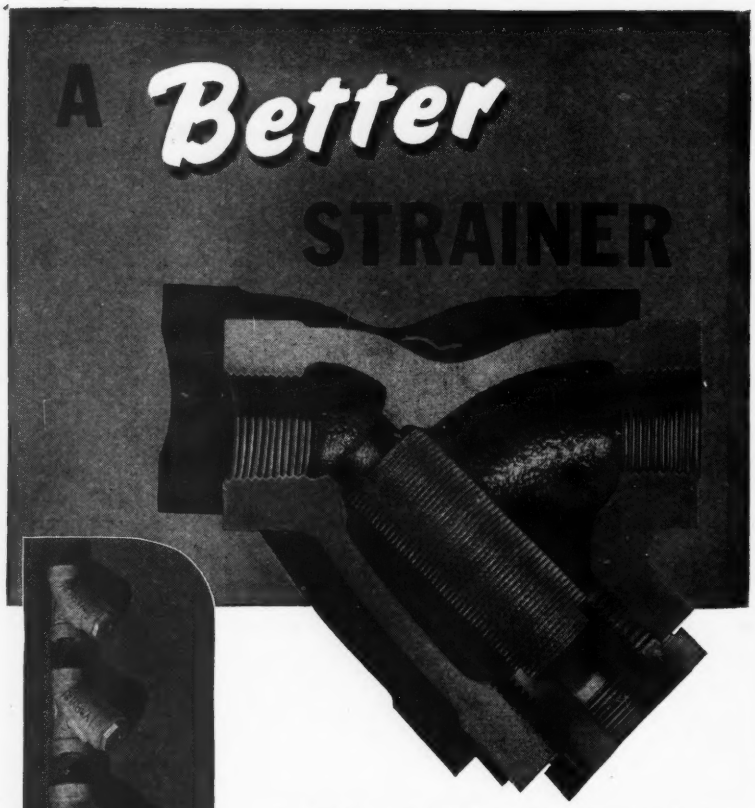

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YARWAY STRAINERS

the small sizes, following which the authors discussed the four classifications of stokers which are available for semi-industrial applications with small size anthracite. These stokers are: (1) Underfeed stokers, subdivided into two types (a) moving grate bar, (b) stationary-grate bar; (2) Chain grate stokers; (3) Spreader stokers, (4) Traveling grate stokers.

Bituminous Stokers

In his discussion of Application of Bituminous Stokers, H. L. Wagner of the Detroit Stoker Co., confined his remarks to the group of plants burning bituminous coal, in size ranges from 3000 to 20,000 lb of steam per hr., consuming coal at the rate of from 1000 to 8000 tons per year. He emphasized that due to the rising costs of labor, material and fuel, it is important that each plant be thoroughly analyzed before selecting the coal burning equipment. There are many conditions to be considered, namely: size of the plant and its location, the type of load, heating, power or process, minimum, maximum, and rate of fluctuation. The analysis of the coal available is important, especially the amount and the fusion temperature of the ash. The size and burning characteristics of the coal should also be considered. The boiler should be selected with a view of getting the proper combustion volume, amount and location of water cooled surface in the furnace and suitable for the stack draft and breeching design available.

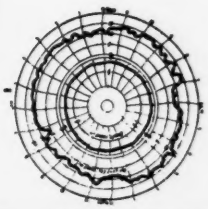
Stokers suitable for this class of service, he stated, can generally be classed as the single retort underfeed and the spreader type with stationary or intermittent dumping grates and the continuous cleaning grate. He then discussed in detail the characteristics and application of each of these types of stokers. He pointed particularly to the restrictions surrounding the application of each of these types of stokers, their range of physical dimensions, the burning rates per square foot and the rate of heat release per cubic foot of furnace space, their relative tendencies to produce smoke and fly ash and the advisability of providing accurate combustion control methods of the automatic type in connection with furnaces for the burning of this type of coal.

The design of plants from a consulting engineer's viewpoint was discussed by Harold N. Hermann, President of Harold N. Hermann & Associates, Inc., who emphasized that the following six major considerations must be taken into account:

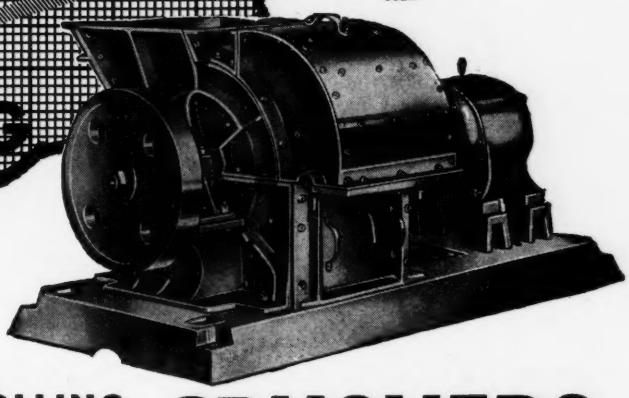
1. Service, Character of Load, and Stand-by Capacity.
2. Location of Plant and Its Influence on Design.
3. Operating Personnel.
4. External Influences.
5. Equipment.
6. Fuels and Furnace.

Each of these topics was discussed briefly and the author emphasized

INCREASE COMBUSTION EFFICIENCY through UNIFORM COAL SIZING



Uneven combustion recorded from improperly crushed coal.



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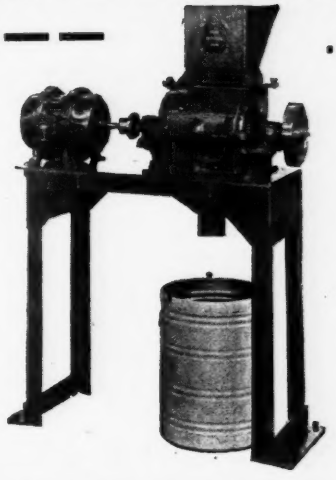
Stoking with coal uniformly sized by American Crushers increased firing efficiency (as recorded by CO_2 charts) from 2½ to 8% over coal prepared in conventional crushers. A series of impartial 24 hour operating tests run by an independent agency (name on request) has proven this, and the fact that the quality of the crushing is largely more important than the quality of the coal in efficiency of combustion.

Americans provide a compact, complete crushing operation in minimum headroom. No auxiliary crushing operations or equipment are necessary—no extra picking or standby-cleanout labor required.

American's exclusive manganese steel shredder rings rapidly and efficiently reduce ROM coal to stoker or pulverizer sizes with minimum fines and no oversize at a cost of less than 1c a ton.

American Type "S" Crushers, especially designed for power plants, are built in 9 different sizes, with capacities from 25 to 500 TPH.



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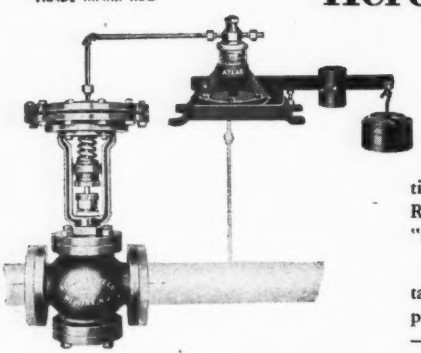

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In other words, if you want to maintain pressures within fractions of one pound—and without perceptible variation—specify an ATLAS Super-Sensitive Regulator.

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This remarkable regulator accommodates itself to an almost limitless range of applications. It regulates, accurately, between the initial pressure and atmosphere in one stage, operating control valves from ½" to 6".

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- ☐ Exhaust Control Systems
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- ☐ Float Valves
- ☐ Oil Control Cocks
- ☐ Humidity Controllers
- ☐ CAMPBELL Boiler Feed Water Regulators
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that with the ever increasing cost of fuel, it becomes increasingly important that adequate combustion control facilities be included in most of these plants. In most instances a master regulator tied in with the coal and air supply supplemented by over-fire draft regulator will be adequate. "We should not overlook the fact that the spread between the cost of coal and other types of fuels is shrinking. Competition between fuels is increasing. The only alternative is to design the plant so that lower grade coals can be burned efficiently and with freedom from operating troubles."

Directing his paper entitled "Instruments and Combustion Control for Plants," toward the smaller type of steam generating plants in the range of approximately 3000 to 20,000 lb of steam per hour output, or consuming between 1000 and 8000 tons of coal per year, W. H. Pugsley, Vice President in Charge of Field Research for The Hays Corporation, pointed to the benefits of instruments and combustion control and their possible arrangement to fit the individual plant requirements. In this discussion he considered the application of such instruments as draft gages, steam flow meters, feedwater heaters, combustion guides like the orsat, the automatic carbon dioxide recorder, and the airflow to steam flow relationship and mentioned other instruments such as pressure gages in the main header, temperature and pressure of feedwater, and temperature of the flue gases at the outlet of each steam generator.

Mr. Pugsley spoke of the purpose of the instruments as a guide to the firemen in their efforts to generate steam most economically, that is to save fuel dollars. To the chief engineer or management they tell a story and serve in governing the plant operations and for cost accounting. Automatic combustion control was spoken of as primarily a means to increase the efficiency of combustion and thereby save dollars. Automatic combustion control systems can be divided into two general types: positioning and metering. Both systems operate on the same general principles; both respond to changes in steam pressure as being representative of changes in demand for heat input to the steam generator. Mr. Pugsley urged that management, designing and operating engineers alike look well to the future in the building of power plants. If proper consideration is given not only to the design efficiency of the steam generator but also to what the daily operating costs and working conditions will be, instruments and automatic combustion control will be given their proper place in the scheme of things.

Economics in boiler room operation was discussed by C. E. Miller, Asst. Chief, Utilities Operations Branch, Office, Chief of Engineers, Department of the Army. Mr. Miller stated that during the past few months many hundreds of small boiler plants have

SERVICE TO INDUSTRY

More than 1,000 modern steam generators ranging in size from 10,000 to 1,200,000 lbs of steam per hr, installed or contracted for since V-J Day, attest the soundness of conservative design in theory and practice.

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The changing fuels pattern, accelerated by the war, involves competitive relationships, higher delivered fuel costs, diminishing reserves of premium fuels, and shifting markets, and brings a new demand for conservative design of steam-generating units. Utilities and industrials, whose fuel requirements are increasing, now recognize these facts in designing their new plants for troublefree, economical, long-range operation.

Today a boiler unit will burn its original cost in fuel in one year, or less. The small additional investment (not exceeding 10%) required for full fuel flexibility will be returned manyfold by making possible the use of the most economical coals the market affords. The Fairmont Coal Bureau, supported by coal producers, has aided thousands of coal users and is committed to the economical utilization of coal.

The Bureau is serving industry through technical bulletins and papers, fuel studies, educational advertisements and conferences. To further serve the needs of industry a mailing list is maintained for over 10,000 plant engineers, operating personnel, and executives, interested in the economical utilization of fuel.

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PG 1-48

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been converted from coal to oil or gas, even though many of these plants are located in normal coal territory. These conversions have been made in spite of (1) coal being the logical fuel and (2) the fact that our reserves of oil and gas are definitely dwindling. Fuel and operating labor are the major costs, he pointed out, in the operation of these small plants. It is his opinion that if the small coal fired plants are adequately provided with automatic equipment, coal can be made a competitive fuel with oil and gas. This fact is true in small boiler plants as one operator is required per plant regardless of the fuel used.

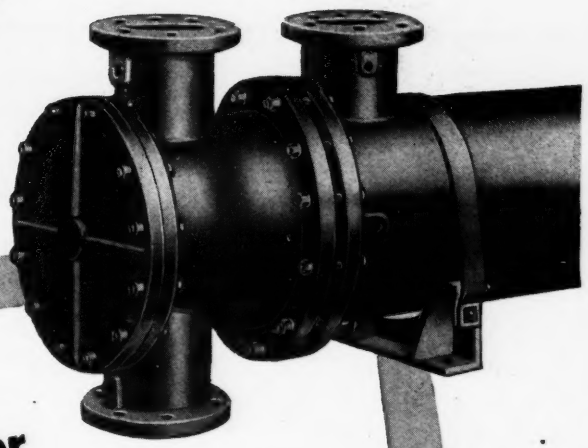
Mr. Miller in his discussion analyzed the operating costs of typical plants of the coal-fired and oil-fired types. He pointed to improved design and how it reduces labor costs. He also suggested methods to effect better design. In his conclusions, he stated that in the past few years a good deal of outstanding work has been accomplished in improving the combustion efficiency and in the choice of proper coal burning equipment for new plants. These efforts have made a substantial contribution to improved plant economy. Now it is time to take the second step by analyzing overall operating costs with a view to making these small plants more automatic. This is not only the answer to lowered operating costs, but is also a major factor in reducing the present tendency toward more and more conversion from coal to oil. When we consider that consumption in these small plants represents almost 10 per cent of the total coal production, efforts along these lines will pay real dividends.

Smoke and Air Pollution

During the past 18 months, the Coal Producers Committee for Smoke Abatement has made engineering surveys to determine the sources of smoke and air pollution in approximately 13 large cities and many smaller cities. This work was reported at the Conference by H. B. Lammers, Director of Engineering for the Committee, who stated that these surveys were made at the request of the officials of each municipality surveyed, in recognition of the fact that they were confronted with a smoke problem and because they desired the recommendations of the Committee as to the most feasible and effective solution to that problem. Mr. Lammers in his discussion outlined some conditions and underlying factors contributing to air pollution in the cities of the United States as shown in the surveys during the past 7 years.

Data gathered during these surveys shows conclusively that undue emphasis has been placed on mechanization alone without proper follow-up as a solution to that problem. In all too many plants the personal equation has been overlooked, relegated to the background and forgotten. It is obvious, he said, after examination of

Beware of fouling...



Tube deposits can insulate your cooler against adequate heat transfer

DIMINISHING efficiency of your cooling equipment may mean that insufficient attention has been given to the fouling tendencies of fluids circulated. Watch for this in determining your cooler design. Either fluid, by its very nature or through local conditions, may be the type to leave a heat resistant residue on the inside or outside of the tubes. This acts as an insulation against heat transfer. Result: diminishing heat transfer rate and increasing maintenance beyond practical limits!

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Ross heat exchange engineers will quickly determine for you: proper velocities to minimize residue; temperature ranges necessary to discourage precipitation of carbonate on the tube wall; and correct fluid to be circulated through the tubes. Contact any Ross office, or write *Ross Heater & Mfg. Co., Inc.*, (Div. of American Radiator & Standard Sanitary Corp.), 1428 West Ave., Buffalo 13, N. Y.

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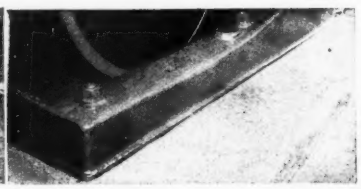
STEAM ENGINE FRAME

Before

After



20 IN. DIESEL CRANKSHAFT

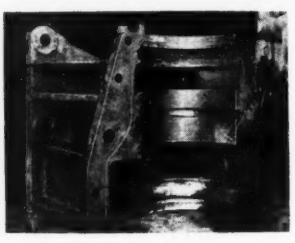
Before

After

PLUMMER BEARING (Navy Photograph)

Before

After



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thousands of plant conditions, that we must make a new approach to this problem. We must hold on to all we already know, but we must increase the efficiency of human machines to the position that our mechanical units have already attained. We must row our "smoke elimination" boat with two oars; the oar of mechanization and the oar of intelligent human use of mechanization.

In relating his experiences with government-operated plants, J. F. Barkley, Chief, Fuels Utilization Division, Bureau of Mines, Department of the Interior, stated that the first difficulty encountered in the design of a new, small plant is almost invariably the designer's lack of experience in actually operating a plant. Designers are not operators, and operators are not designers. It is really difficult to get them together so that the best results are obtained.

Other factors he mentioned were limitations of initial expenditure and lack of adequate space which greatly hamper satisfactory design. A designer usually has a host of factors that must be evaluated relatively. Among these factors he discussed the type of water tubes used in boiler design; also the range of fuels which can be used on various types of stokers; he spoke of controls which should be simple for maintaining the proper draft in the furnace and giving increased air when the steam pressure drops and believes that there are opportunities for improving reasonably priced coal- and ash-handling equipment in small plants. He stated that usually sufficient attention is not given to include a simple method of chemically treating feedwater.

COMING EVENTS

Materials Handling — Second Materials Handling Exposition, to be held January 12 through 16, 1948, with headquarters at Cleveland Public Auditorium, Cleveland, Ohio.

ASCE — 96th Annual Meeting of the American Society of Civil Engineers to be held in New York City, January 21 to 24, at the Hotel Commodore.

Refrigeration and Air Conditioning Exposition — Fifth All-Industry Exposition; to be held January 26 through 29, with headquarters at Cleveland Public Auditorium, Cleveland, Ohio.

Air Conditioning Exposition—Eighth International Heating and Ventilating Exposition, to be held in New York City, February 2 through 6, headquarters at Grand Central Palace.

Stoker — Chicago Stoker Exposition; to be held in Chicago, March 11 to 17, inclusive, at the Commonwealth Edison Assembly Hall.

Chicago Technical Conference — To be held March 22 to 24 in conjunction with the annual Chicago Production Show, at the Stevens Hotel.

Midwest Power Conference—Tenth annual Midwest Power Conference; to be held in Chicago April 7, 8 and 9, at the Sheraton Hotel (formerly the Continental Hotel).

Refrigeration — Second annual Western Refrigeration Educational Exhibit and Conference; to be held in San Francisco April 30, May 1 and 2, at the Palace Hotel.

This new seating arrangement

PUTS WEAR IN THE PROPER PLACE

Newly designed Jenkins gate valve uses hard, corrosion-resistant wrought Monel seat rings to assure tightness... at steam pressure up to 200 lbs.

JENKINS BROS.... well-known valve makers... have taken another big step ahead with their newly designed 270-U valve, shown at right.

As you probably know, the abrasive wear of steam and sharp particles under high pressures has long been a threat to the service life of many valves.

But look at the seating arrangement in this new Jenkins valve! The wedge is high-quality bronze — strong enough to last through many openings and closures, yet inexpensive and easy to replace.

For the seat rings — where the constant heavy wear comes — Jenkins Bros. have used Monel*. Work hardened to 190 Brinell or 2½ times harder than the wedge, they'll hardly ever have to be replaced. And since they are made of *wrought* Monel, Jenkins was able to hold the price of this new valve in the moderate range.

In tests, these seat rings stood up under thousands of openings and closings, at 200 lbs. steam pressure without a sign of wear.

These Monel seats fight corrosion, too... another reason why Jenkins especially recommends this valve for severe conditions, such as those encountered in oil refineries, dye houses, as well as chemical, food, and rubber plants. Moreover, the Monel seats are galvanically neutral to the bronze wedge and body metal — even in salt or polluted water.

* * * *

What's your metal problem? If it's hardness, corrosion-resistance, strength, heat resistance, or a combination of these, find out about Monel and the other INCO Nickel Alloys.

With INCO, solving metal problems is a privilege. A brief letter concerning your requirements will start us working for *you*. Write today.

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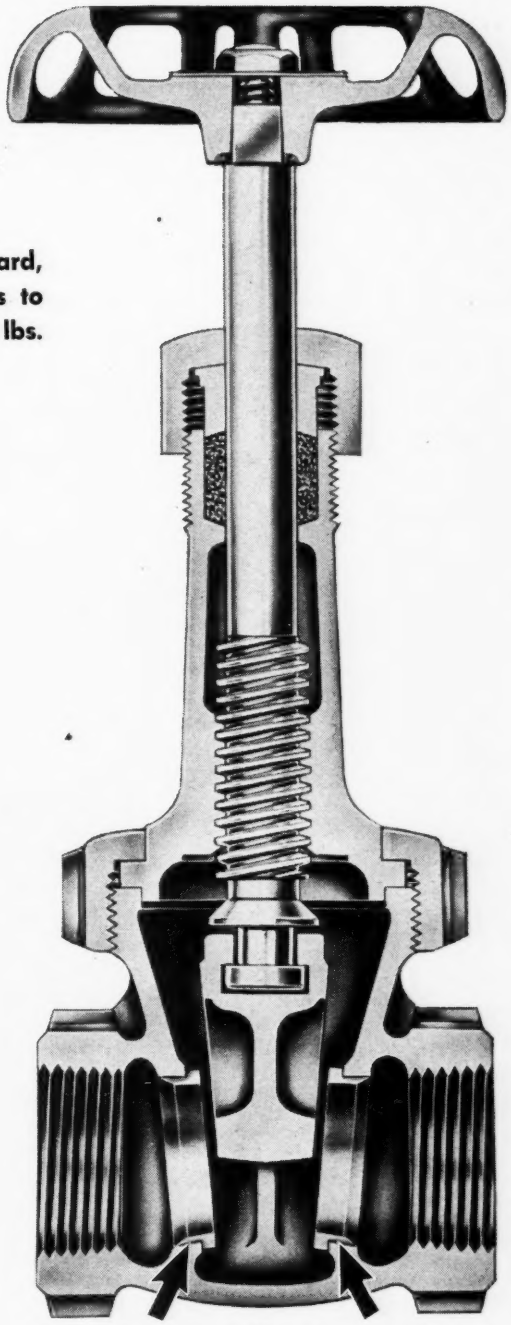

Cross section of new Jenkins valve. Arrows indicate wrought Monel seat rings expanded into valve body which resist wear and corrosion. Tight-fitting bronze wedge is easily replaced, enabling valve to last indefinitely. Available in ¼" to 2" sizes to handle 200 psi steam or 400 psi water, oil, or gas.

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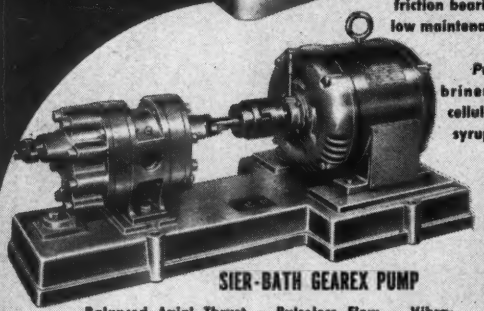

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Obituaries

J. H. WALKER

J. H. WALKER died at his home recently after a severe illness.

Mr. Walker, a vice president of The Detroit Edison Company, was an engineer-executive of the company for many years, and was first employed by it in 1912. He was elected a vice-president in 1945. Before his election as a vice president, Mr. Walker was assistant to the general manager and was active in organization planning and as a consultant on various commercial and engineering problems.

Mr. Walker was a mechanical engineer who graduated from the University of Michigan in 1911 and obtained his masters degree in engineering in 1937.

In November of this year he was given the F. Paul Anderson Award by the American Society of Heating and Ventilating Engineers for outstanding scientific achievement in the field of heating and air conditioning. Mr. Walker achieved national recognition in this field and was for many years superintendent of the central heating department which supplies steam to the principal buildings in downtown Detroit. He was the author of books and technical articles in this field. He was a member of Sigma Xi and Tau Beta Pi and several technical societies.

Mr. Walker was born in Detroit in 1890 and with Mrs. Walker resided in Birmingham, Michigan. They have two children, James H., Jr., of Philadelphia, and Morley who attends the University of Chicago.

B. F. WEADOCK

BERNARD F. WEADOCK, former executive vice president of the Edison Electric Institute of New York, died recently at his home of a heart attack. His age was 63.

Mr. Weadock practiced law for several years in Washington and was associate general counsel for the Commonwealth & Southern.

He was executive director of the National Electric Light Association, 1932-33; vice president and managing director of the Edison Electric Institute, 1933-39. During most of the years he practiced in New York he made his home in Greenwich.

Born in Saginaw, Mich., Mr. Weadock received his LL.B. from the Detroit College of Law in 1905 and in the same year was admitted to practice in Detroit, where he served as chief clerk and assistant corporation counsel, 1907-1912. He was general attorney for the Detroit United Lines, 1912-20; in general practice in Detroit, 1920-24.

Mr. Weadock leaves his wife, who was Mary L. Dillon at their marriage in 1912; two sons, Bernard F. Jr., of Los Angeles, and John Cullen Weadock, of New Milford, Conn., and two daughters, Mrs. James Spence and Miss Shirley Weadock, of New York.

E. F. SCATTERGOOD

EZRA FREDERICK SCATTERGOOD, consulting engineer for the Bureau of Power & Light of the City of Los Angeles, California, and retired head of the bureau, died on November 15, 1947. He was 72 years old.

Mr. Scattergood served for 32 years as head of the Bureau for Los Angeles, retiring in 1940. He was internationally known as an electrical engineer and was a leader in the development of the power and light system of Los Angeles.

He received a degree of B.S. in Mechan-

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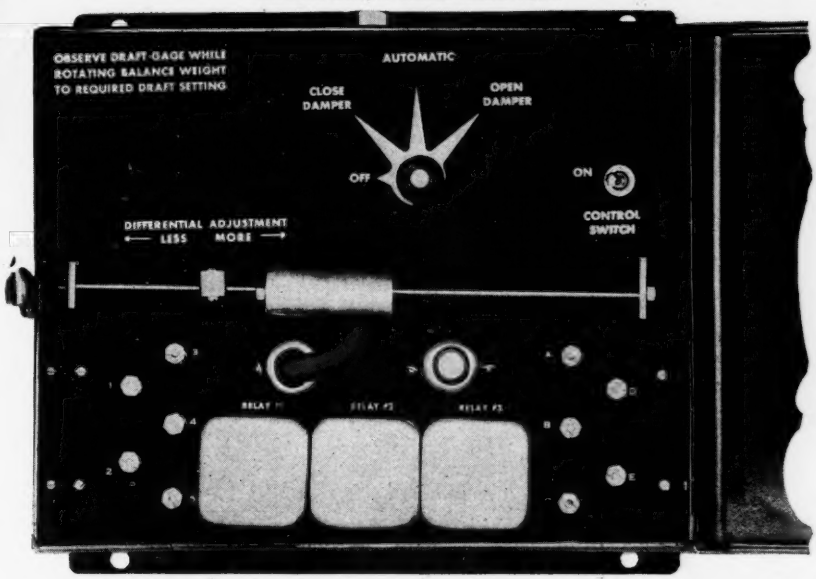
with automatic time-delay features

AT A PRICE YOU CAN AFFORD*

Cleveland Damper Control Model DCR-A



All controls in one compact cabinet which is installed in any convenient location in the boiler room.

- **Simple differential adjustment**—Accessible by merely opening cover.
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- **Replaceable Plug-in Relays**—Easily removable for service.
- **Interchangeable Application Plug**—This one control is adaptable by a quick change of one plug, to

STOKER, OIL, or GAS FIRED

Many operators of medium and small-sized steam boilers have been deprived of the benefits of automatic damper control by the high cost of available control equipment.

The *CLEVELAND* Electric Damper Control now brings automatic operation *within the means of every plant.* This carefully engineered unit provides—in one compact cabinet—all the elements for safe, automatic control of stack draft.

Saves Fuel—Reduces Smoke

In most installations, the *CLEVELAND* Damper Control easily pays for itself in fuel savings in less than a year. It brings the added benefits of *protection to boiler plant equipment, reduction of smoke, soot and fly ash,* and *increasing safety of boiler operation.*

The Cleveland Damper Control has many technical features found only in the most expensive controls. The *Differential Adjustment* may be set to any desired sensitivity by simply turning an easily accessible adjustment knob. The *Selector Switch* gives complete manual control when desired—permitting full stack draft for soot blowing, inspection, etc., also full closed draft for boiler repairs, reduced load, etc. For normal operation, switch is set at "Automatic".

The *Emergency Cut-Out-Switch* makes it possible to instantly cut out all control and return to manual operation.

The *Application Plug* adapts the control to stoker, oil or gas fired boilers. The same control unit may be used with any fuel simply by inserting the proper Application Plug.

Safe, Step-by-Step Operation

The three plug-in relays in the control provide the time delay necessary for safe, efficient control. For *Stoker-fired boilers,* Relay No. 1 is energized when system calls for firing, opening damper. Relay No. 2 gets the signal when damper is open and starts the stoker. When stoker has started, Relay No. 3 places damper on automatic modulated control, which continues until the start of a new cycle again brings in Relay No. 1.

For *Oil- and Gas-fired boilers,* Relay No. 1 opens damper and Relay No. 2 starts ignition system when damper is open. When ignition is established, Relay No. 3 starts automatically controlled draft—and when burner goes off, returns damper to closed position to retain residual heat until new cycle starts.

**Many recent installations in Laundries, Greenhouses, Dairies, Hotels, etc. have been made with the average total cost approximately $350. This includes all accessories—CFE Draft Gauge, CFE Air Pressure Gauge, CFE Pyrometer, CFE Electric Drive Unit and all installation charges. Write for complete information.*

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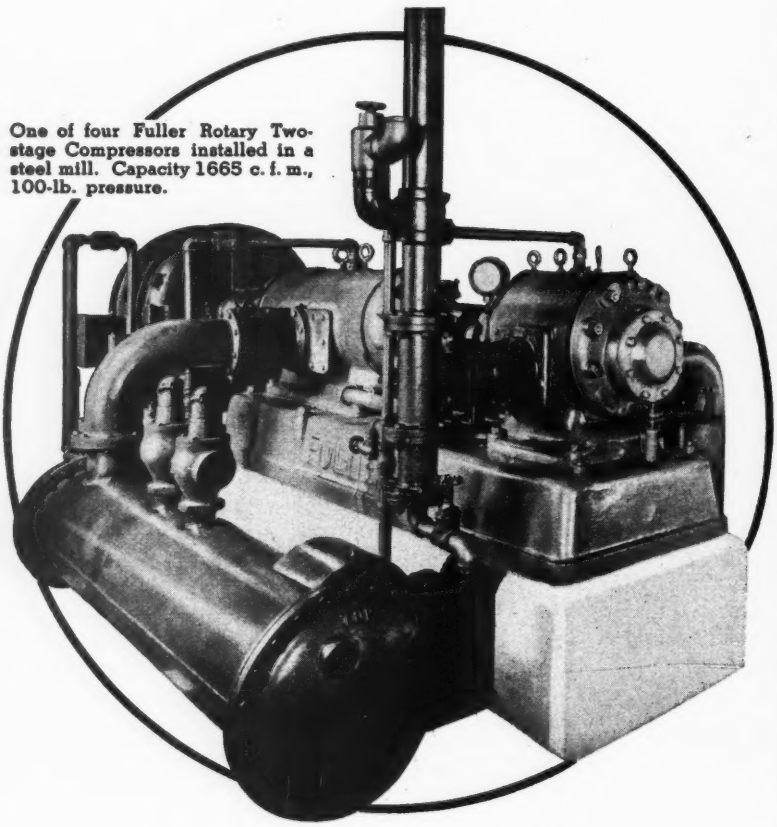

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Bulletin 5-C illustrates and describes Fuller Rotary Compressors and Vacuum Pumps. Write for your copy.

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ical Engineering at Rutgers College; and received the degree of M.M.E. at Cornell University in 1899. He also received a degree of Doctor of Science from Rutgers University in 1931.

He served as a professor of physics and electrical engineering at Georgia School of Technology until 1902. Then he went to Los Angeles, where he was a consulting engineer until 1906. He was then appointed special engineer for the Huntington Light, Power & Electric Railway Companies.

In 1909, Mr. Scattergood became chief electrical engineer and general manager for the recently formed Bureau of Power & Light in the Department of Water and Power.

He was a key figure in the development by the city of its electrical system, in obtaining power from Hoover Dam, in the building of the Owens Valley aqueduct, in the acquisition of the Los Angeles Gas & Electric Company and other projects. He was also a leader in civic and political affairs for many years. In selecting him as "Cosmopolite of the Month" last July, the Cosmopolitan magazine said of him, "Probably no man has contributed more to the creation of this phenomenal western metropolis (Los Angeles) than Ezra Frederick Scattergood."

H. BOYD BRYDON

H. Boyd Brydon died in Victoria, B. C., late in November.

Mr. Brydon was a member of the staff of Byllesby Engineering and Management Corp. (now Public Utility Engineering and Service Corp.) for 21 years, retiring from his position as chief mechanical engineer there in March, 1930. He moved to Victoria and became one of the best known amateur astronomers in Canada, serving as president of the Victoria Centre of the Royal Astronomical Society and as a vice-president of the national society. In 1941 he was awarded the Chant Medal, highest award of the Society.

Mr. Brydon was born in England and educated at Finsbury Technical School, London. He came to Chicago in 1900 and was associated with Sargent and Lundy until 1909, when he joined the Byllesby organization. His work in connection with the design of such steam-electric generating plants as Waterside Station at Louisville, Riverside at Minneapolis, High Bridge at St. Paul and the Colfax and Reed Stations at Pittsburgh is well remembered.

New ENGINEERING BOOKS

Principles of Refrigeration, by William H. Motz, third edition (revised); 672 pages. 215 illustrations; 103 tables; nine fold-in inserts; six charts; six by nine in., cloth binding. Published by Nickerson & Collins Co., 435 N. Waller Ave., Chicago, Ill.; price $8.00.

Since the publication of the first edition of Principles of Refrigeration in 1926, subsequent editions have been revised to include new developments and improved processes, adopted as accepted practice during the interim.

In the original and subsequent editions, the author has presented the elementary and fundamental principles underlying the operation of ice making and refrigerating machinery; the properties and values of principal media used in modern refrigerating apparatus; the application of refrigeration to some of its most important uses.

The book will be found useful for beginners in the study of refrigeration, and as a text-book for students in technical schools. It provides information and data for the practicing refrigeration engineer. It is believed that the work will prove of special interest to erecting and operating refrigerating engineers, refrigerating ma-

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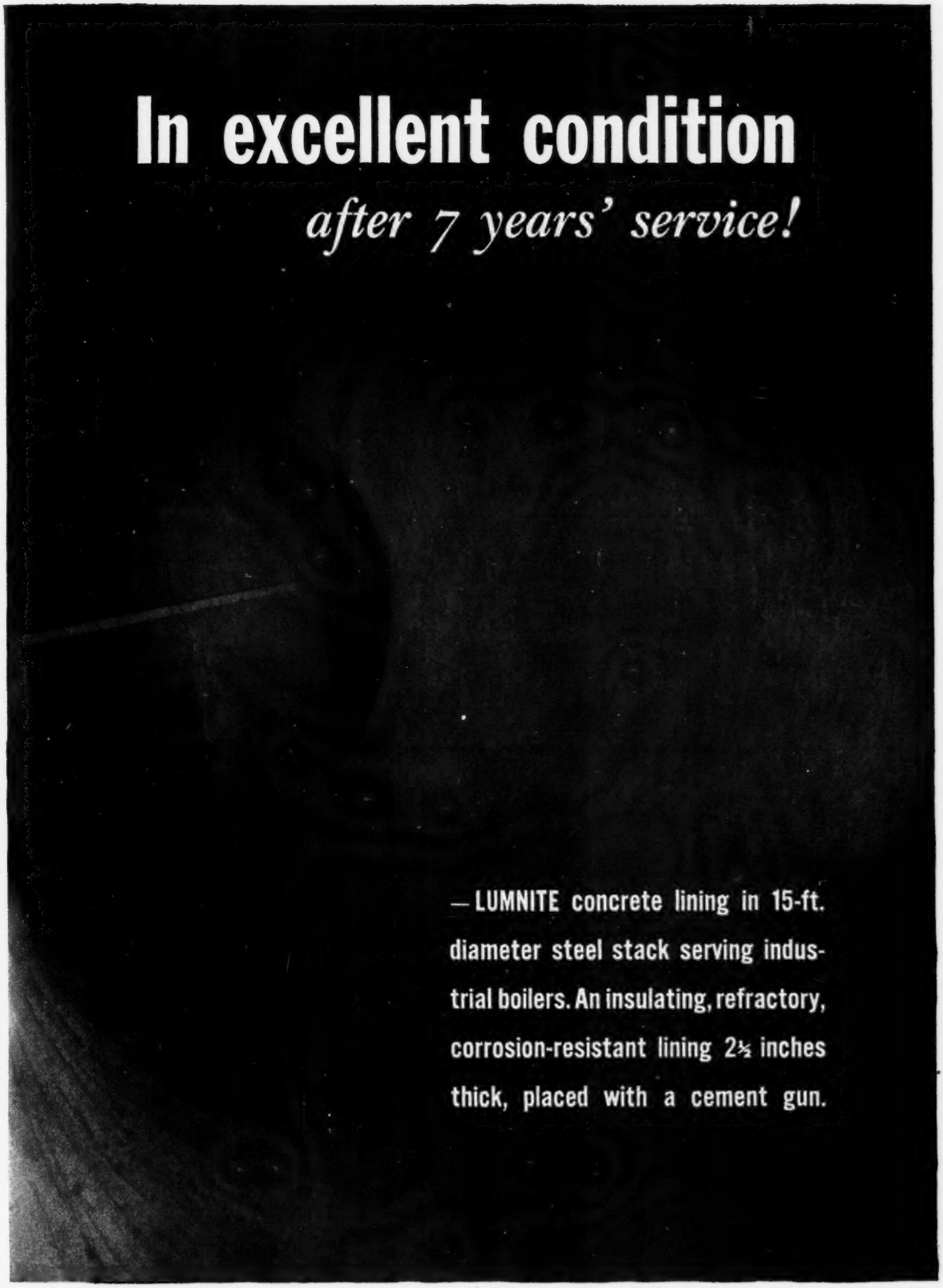

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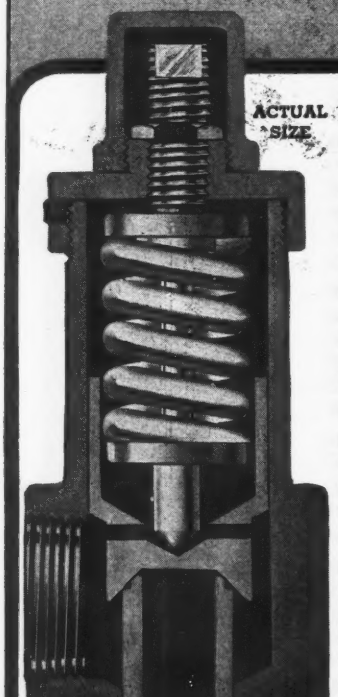

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- **Nozzle seat well above the drain line prevents accumulation of scale or sediment and assures full free opening.**
- **All parts are machined from forged bar stock . . . brass, cold-rolled or stainless steel . . . which permits compact design with sound metal in all parts. All nozzles and discs are of stainless steel.**

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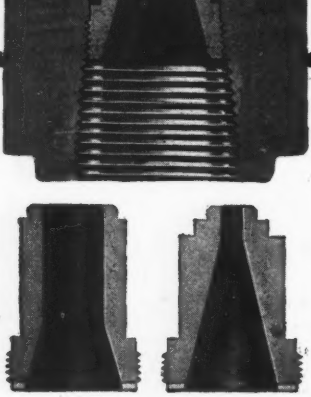

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Size in.	Nozzle Area sq. in.	Max. Pres. psi.	Overall Height in.
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¾	0.077 0.019	2000 10000	5¼
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chinery sales engineers, persons employed in building refrigerating machinery, and those employed in ice making, cold storage plants, or other establishments equipped with refrigerating machinery. In general, the book contains the information the refrigerating engineer should have for complete and up-to-date knowledge of the theory and practice in this field of endeavor.

The work is in every-day language, and as free as possible from higher mathematics. The method of treatment has been to present a comprehensive treatise on the fundamental principles. With a firm grounding in these, the engineer is enabled intelligently to design or operate refrigerating machinery. The theoretical and fundamental operating principles are given attention first. This is followed by numerous practical considerations and the application of the fundamental principles to the economic production of ice and refrigeration for various purposes.

Tube Fitters' Manual, issued by The Parker Appliance Co., Cleveland 12, Ohio, seventy-six pages; price $1.00.

This is an authoritative handbook on the selection, sizing, layout and installation of metal tubing circuits and it makes available basic data underlying the specialized techniques required for the design and quick installation of metal tubing circuits.

Adequately illustrated with photographs, diagrams and charts the handbook covers all phases of tubing systems, with sections on system characteristics, choice of components, sizing, manipulation of flaring and bending tools, circuit measurement and layout and actual installation procedure. Of particular importance are size selection charts, based on flow required, pressures handled under varying services, and temperature conditions for meter and instrument systems.

Slide Rule Short Cuts, by W. P. Miller, E. E. Second edition, 20 pages, 5 by 9 inches, paper; published by W. P. Miller, 536 "F" Street, San Diego 1, Calif., 1946; price $1.50.

This little book explains clearly and quite concisely the how and why of short-cut methods to save time and effort in the use of the slide rule.

Locating the decimal point is clearly explained. Odd Left-Even Right method of locating the digits on the rule. Figuring voltage, current, resistance, wattage, is discussed and the author shows how easy it is to work quickly. The author presents five methods that can be applied to most problems. Series and parellel impedance problems solving on a polyphase slide rule, without the use of tables. The L scale makes calculation of decibel gain or loss comparatively simple with examples to show how the scales are used. Short cuts for use on LL Duplex Cecitrig rules that have trigonometric scales on the slide and a DI scale on the stock are offered. Sometimes it is possible to solve a problem in complex notation without transferring to another scale with the method the author suggests.

Cycles—the Science of Prediction, by Edward R. Dewey and Edwin F. Dakin; 255 pages, illustrated; size 6 by 9 inches, cloth binding; published by Henry Holt and Company, 257 Fourth Avenue, New York 10; price $3.00.

This book presents a completely new approach to the economic problems of our time. It is intended to explain rhythmic cycles that can be demonstrated as effecting the lives of men, the objective being to enable them to predict the economic outlook. It offers, within scientific limits, a key to some of the rhythms of the future.

A cycle is a sequence of events completed within a regular interval and occurring over and over again. If the same thing has happened regularly time and again in the past, it may be quite reasonable to expect that it will happen again on schedule in the future.

In many kinds of natural phenomena,

cycles are known to exist. The word cycle derives from the Greek word meaning circle and implies a coming around to the place of beginning. A cycle does not necessarily imply any regularity in time intervals but rather a sequence of events of the same kind. The rhythm of a cycle is its "beat." The period of the cycle denotes a cycle which repeats itself at mathematically exact intervals. This does not exist in nature but we have close approximations to it.

The authors of this book, after discussing such things as why trends are important, patterns and growth of organisms, and the growth trend in our basic industries, analyze some rhythmic cycles in natural phenomena such as the abundance of certain types of animal and insects as well as fish and mammals. They show how many of these are related to the solar constants and even to variations in human emotion.

They then analyze certain occurrences, such as those in wholesale prices, which take place in a 54-year rhythm and also in a 9-year rhythm. They show variations in common stock prices occurring in a 3½-year rhythm. They point out that there is an 18-year rhythm in the field of building activities, also in marriages, wheat acreage, brick production, pig iron production, and railroad stock prices, as well as many others. There are chapters on causes, correlations, and conjectures about all these cycles. A chapter is included on timing a business, another on avoiding some economic illusions.

The chapter on the relation of war to the normal cycles is extremely interesting, for a number of curves are plotted to show that after any given war, we at least did know what happened. The interesting thing is that a distortion of a cycle curve produced by war is of relatively short duration and that the curve very shortly afterwards begins to take the same direction that it probably would have taken if there had been no war. The authors discuss this at considerable length. The book concludes with discussions of post-war trends and post-war rhythms.

Practical Descriptive Geometry, by S. E. Rusinoff; 259 pages, illustrated; size 5½ by 8½, cloth binding; published by American Technical Society, 58th at Drexel Ave., Chicago 37, Illinois; price $3.50.

The primary objective of this book is to develop the principles of descriptive geometry in the conditions under which it will be used in actual engineering and drafting room problems and situations. The author, who is Assistant Professor of Mechanical Engineering at Illinois Institute of Technology and a consulting mechanical engineer, has endeavored to remove the mystery and confusion that have shrouded this subject. He shows how the subject is alive and has a most practical and useful application in everyday engineering work.

He maintains interest in the subject by continual reference to the application of each principle in a wide variety of practical apparatus such as airplane wings, piping, ducts, automobile fenders, machine design, etc. Simple terms are used to express methods and procedures.

The first two chapters give a condensed review of engineering drafting and the application of the basic principles of geometry and drafting. The principles of projection are clearly explained. The author emphasizes the correlation between orthographic drawing and descriptive geometry as they relate to practical problems.

Following chapters apply the principles of descriptive geometry to the design and assembling of machines and parts. The introduction of a principle is followed by its application to an industrial problem.

In the last chapter, the author discusses many short cuts learned in over 25 years of experience as a teacher and designer for automotive companies and die builders and as a consulting engineer. An appendix gives practical tables such as those for squares, cubes and roots of numbers, logarithms and trigonometric functions.

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SAVE EQUIPMENT—The Henszey Blowdown System prevents priming, foaming and carryover . . . and also prevents the formation of scale by simple chemical treatment of the feed water. Boilers last longer and tube burns are kept at a minimum. The resultant clean steam makes packings last longer — reduces wear on rods and cylinders —reduces turbine blade erosion — prevents sticking of reducing valves, traps, etc. — prevents superheater burnouts.
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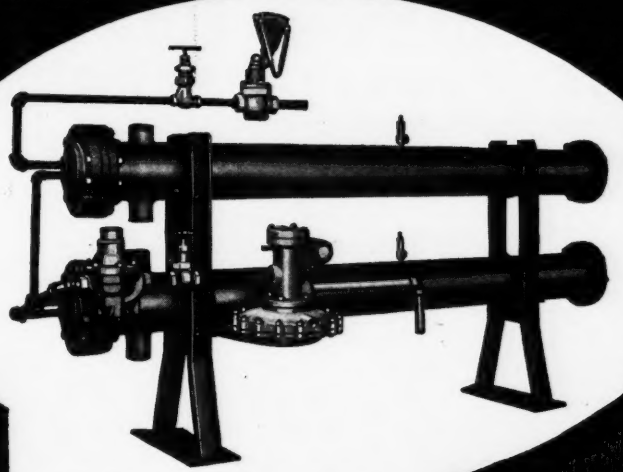
SAVE FUEL — The Henszey System offers complete, automatic blowdown without heat loss — a big fuel saving in itself. Then, too, boilers free from scale and sludge are more efficient — they require less fuel to produce the power load.



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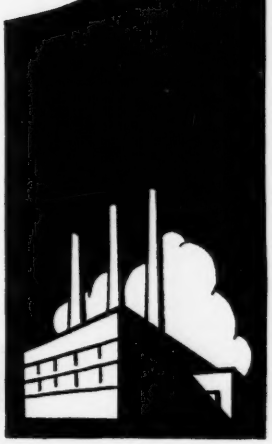

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This monthly list of the latest standard catalogs and bulletins is designed to aid the engineer in maintaining his permanent catalog file of engineering data. The items listed, unlike those under Helpful Bulletins, will appear each month except for additions and deletions dictated by space requirement or by the manufacturers issuing the bulletins. Use the Helpful Bulletins coupon in requesting these copies.

BOILERS

51 Steam Generators—Catalog almost completely devoted to cross-sectional drawings with accompanying listing of principal data of typical installations in rubber companies, steel works, sugar refineries, municipal plants, etc. Details of furnace water wall construction on inside back cover; 16 pages. Henry Vogt Machine Co., Inc.

52 Double-Pass Boilers—Bulletin R-M-1 (6th edition); illustrates and describes this line of riveted or welded double-pass steel firebox boiler. Three full pages of dimensions, ratings and other details including dimensioned line diagrams; 8 pages. The Brownell Co.

53 Boilers, Burners, Accessories—Bulletin GC-10; condensed catalog of regular products for stationary power plants. Each class of equipment summarized and illustrated with line drawings and photographs. Illustrations accompanied by brief descriptions; 12 pages. Combustion Engineering Co., Inc.

54 Standardized Boilers—Bulletin 746; 4 page bulletin presenting construction and operation information and ordering specifications for this company's Type M boilers. Bulletin illustrated, presents table of measurement and data. Springfield Boiler Co.

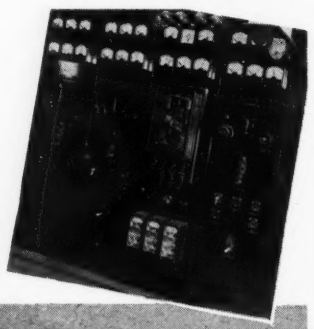
55 Steam Generators—Presents reason for high efficiency; shows brief case histories of plants. Results of tests by independent authorities and "Facts You Should Know About Steam Generating Units." Ratings, dimensions and other data presented. Springfield Boiler Co.

56 Steam Generator—Bulletin 119; company's Type S steam generator described and features of construction are pointed out. Folder well illustrated and dimensioned drawings and table of dimensions and sizes are given. Union Iron Works.

57 Stirling Boilers—Bulletin describing Type H Stirling boiler for low-head room use. Several specific installations of the unit are cited, dimensional data are given for various sizes and capacities of the units. The Babcock & Wilcox Co.

3 Complete, Modern

575 KVA SKINNER UNAFLOW ENGINE GENERATOR UNITS



3—750 HP Skinner unaflow engines, each directly connected to 575 KVA Westinghouse 220 volt, 3 phase, 60 cycle, 150 RPM alternating current generator, with 15 KW "V" BELT DRIVEN EXCITERS.

Complete switchboard control apparatus, with switchboard operated variable speed synchronizing devices and automatic voltage regulators.

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3—surface condensers with motor-driven circulating pumps.

3—250 HP low pressure condensing steam turbines with auxiliaries.

This plant is one of the most modern medium-size steam power plants on the West Coast. It is complete in every detail.

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PRIME MOVERS

58 Axial Flow Impulse Turbine—Bulletin S-107; six types described; data for estimates; applications types, casings; wheels and blades; shafts, nozzles and bearings; overspeed stop and other governor features; lubrication; 8 pages. The Terry Steam Turbine Co.

59 Multi-Stage Turbine—Bulletin SR-114; Casing, lagging, wheels and blades; shafts, nozzles, bearings; governors; speed changer or synchronizer; governor valve and steam strainer; lubrication; general; 10 pages. The Terry Steam Turbine Co.

60 Turbines, Pumps, Products—This 24-page catalog covers the company's complete line of products from steam turbines to flexible couplings. Every product is discussed from the design and operation angles and the discussion is heightened in interest by the inclusion of many excellent photographs. Other products discussed are helical gears, centrifugal pumps, multi-stage pumps, screw pumps, blowers, compressors and speed reducers. De Laval Steam Turbine Co.

61 Turbine Cleaning Manual—This 20-page bulletin covers the step-by-step solvent and manual cleaning of turbines from the inspection and preliminary cleaning to draining and final inspection. The cleaning and bearings and governor, installation of filter unit, circulation of cleaning solvent, and displacement of cleaning oil with new lubricating oil are steps which are covered briefly but clearly. Shell Oil Company, Inc.

62 Steam Engines—Bulletin No. 306; Engineering data; tabular material, descriptions; 8 pages. Troy Engine & Machine Co.

63 Generating Sets—Bulletin No. 108. General description, typical installations, engineering data tables, details of construction, completely illustrated; 24 pages. Troy Engine & Machine Co.

64 Stationary Diesel Engines—Dependability, adaptability of Diesel power described and applications pointed out. Its economical and simple design is stressed. Advantages of company's equipment brought out; exceptionally well illustrated; 24 pages. Enterprise Engine and Foundry Co.

65 Steam Engines—Bulletin 306 describes vertical steam engines. Full page table of engineering information on Types E and ST engines is presented as is a section on construction details of such parts as piston and rod, cross head, crank shaft, etc. Well illustrated. Troy Engine & Machine Co.

66 Mechanical Drive Turbines—Bulletin H-16 gives direction on selection of a unit and tabular material or general specifications and material specifications. Twenty one of the unit's features are pointed out and a large sectional drawing and a table of dimensions and a dimensioned line drawing also are shown. Elliott Co.

ELECTRICAL

67 Oil Circuit Breaker—Bulletin 71B-6421 describes Unitop oil circuit breakers; ratings from 15 to 46 kv. 500,000

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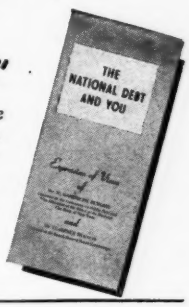

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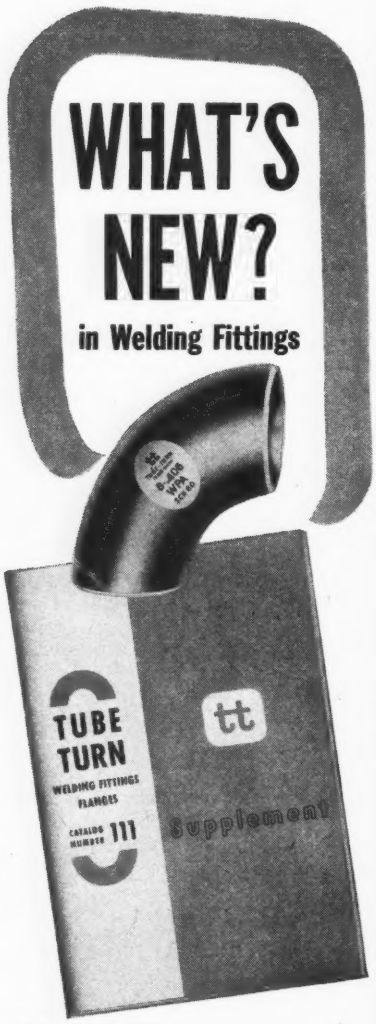

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to 1,500,000 kva interrupting capacity. Well illustrated. Allis-Chalmers Mfg. Co.

68 **Generating, Substation Equipment**—Bulletin 25B6150 titled "More Power to U.S.A." 32 pages; sketches coverage of the company's equipment from hydro and steam turbines to switchgear and circuit breakers. Unusually well illustrated. Allis-Chalmers Mfg. Co.

69 **Fuse Booklet**—16-page pocket size booklet tells of outstanding construction features of fuses—such as the renewable link and spring tension locking of links in circuit. Full-page wash drawings are used to emphasize features. Two pages of price and specification data are included. Ware Brothers.

70 **Electrical Precipitation**—Cottrell Process is described and three gas cleaning problems—recovery of valuable material, cleaning for subsequent use, and the elimination of a nuisance are covered. Research Corp.

AUXILIARIES, ACCESSORIES

71 **Strainers and Separators**—Bulletin 46-50; describes complete line of company's strainers and separators. Dimensioned drawings and photographs; tables of sizes and complete description of applications, operation and design; 16 pages. American District Steam Co.

72 **Atomizing Deaerators**—Bulletin 4160; 3 color drawing illustrates description of principle of operation. Advantages of deaerators are described and illustrated; marine deaerators also covered; 20 pages. Cochrane Corp.

73 **Condensate Return System**—Description of operation and possible savings accompanied by line diagram and description of how "Jet-Loop" works; typical installation pictured and described. Drawings and text show proven results from experience of users, 2-page spread of drawings and table of dimensions; 16 pages. Cochrane Corp.

74 **Low Pressure Evaporators**—Description of L. P. evaporators; types of evaporator plants, listing of advantages of L. P. submerged tube evaporators. Line diagrams illustrate principles brought out in descriptions. Typical installations are considered and analyzed; 12 pages. Condenser Service and Engineering Co., Inc.

75 **Power and Industrial Equipment**—Bulletin Q-12; describes and illustrates company's equipment for power and industrial use—steam turbines, motors, generators, feedwater heaters, turbo-chargers, steam jet ejectors, centrifugal blowers. Exceptionally well illustrated; 20 pages. Elliott Co.

76 **Heat Exchanger**—This new bulletin describes the company's Twin G-Fin Section; Buletin 1614; section characterized as universal heat exchanger. Bulletin tabulates 21 features and corresponding advantages, describes design and construction. Installation views shown, field reports included; 16 pages. The Griscom-Russell Co.

77 **Evaporators**—Bulletin 364 describes, illustrates exporators for various capacities and pressures; contains sections of special interest to plant engineers and executives; includes explanation of functions of evaporators, benefits obtained by their use; different types of evaporating systems and their association with plant balance. 26 pages. The Griscom-Russell Co.

78 **Soot Blowers**—Bulletin F45; soot blowers in general are described. Description and operation of units, materials and specifications and other pertinent information is presented; tables of steam consumption, boiler efficiency, fuel saving chart; boiler cross-sections with blower locations indicated thereon and installation drawings and data are included; 10 pages. Marion Machine, Foundry & Supply Co.

79 **Water Heater Capacity Ratings**—14 tables are included in this ratings booklet showing capacity ratings per hour for temperature rises of from 20 deg (50 to 70 deg) up to and including ratings for a 150 F temperature rise (50 to 200 F). Table No. 15 presents the rate of flow of steam through pipes with steam from an initial gage pressure of one pound up to 150 psi. Marion Machine, Foundry and Supply Co.

80 **Open Heaters**—Publication 4091, 24 pages, covers three lines of open heaters for direct contact heating of boiler feed water and industrial process water. Characteristics of design and operating information and installation photos are presented. Cochrane Corp.

81 **Coal Weighing Scales**—Description; outstanding features, specifications,

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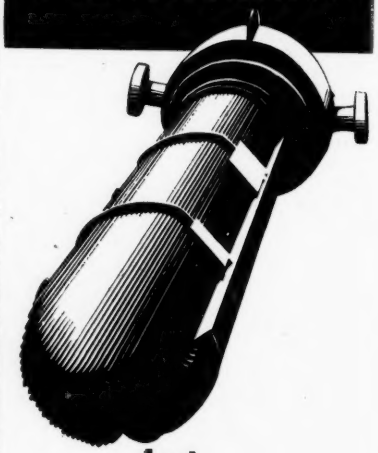

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line drawings, photos; 4 pages. Beaumont Birch Co.

82 **Steam Specialties**—Collection of folders steam trap, air trap, reducing valves, classes E, B and H pump governors, automatic boiler feedwater controller; parts and units list prices; descriptions; illustrations; tables of capacities. The C. E. Squires Co.

83 **Deaeration**—Data book; No. N-15 gives reasons for and principles of deaeration; cold water deaeration; tabular drawing and chart material presented; well illustrated; 20 pages. Elliott Co.

84 **How to Choose a Steam Trap**—Trap selection, trap rating, trap capacity factors, individual trapping, determining lift; traps for unit heaters, pipe coils, fan system heating surfaces, steam jacketed kettles, autoclaves, laundry equipment, paper makers, etc.; installation, operation, maintenance, instructions; specifications and capacities, corrosive service; 42 pages. The V. D. Anderson Co.

WATER TREATMENT

85 **Index for Calcium Carbonate**—Reprint of paper by John W. Ryznar; tables and charts; 16 pages. National Aluminate Corp.

86 **Boiler Feedwater Q & A**—Bulletin 30; 102 questions and answers on various problems of boiler feeawater; 16 pages. National Aluminate Corp.

87 **Water Treatment**—Scale and corrosion control in potable water supply; reprinted paper presented by Hanlon, Steffen, Rohlich and Kessler; 12 pages. National Aluminate Corp.

88 **Water Conditioning Service**—"The 6 Fundamentals of Betz Water Conditioning Service" illustrates and describes how this company extends a supervisory service for boiler water conditioning. Booklet shows complete operation of these 6 steps; 16 pages. W. H. & L. D. Betz.

89 **Water Softener**—Bulletin 607; benefits and economies of soft water; typical applications; how it works; types; design and features; backwash and brine rinse regulators; how to modernize present softener; aerators, degasitors, chemical feed systems, chemicals; 20 pages. Elgin Softener Corp.

90 **Softener Handbook**—Manual, semi- and full-automatic zeolite water softeners are covered in Bulletin 315. Water softener plant is discussed in the first section and operating cycles and plant supervision is next considered. The third section is "Selecting Manual or Automatic Equipment"; this is accompanied by a table of comparison data. Graver Tank & Mfg. Co., Inc.

91 **Hot Process Water Treatment**—Form 326 is a case study bulletin; covers results of an installation of the company's hot process equipment at Kankakee Ordnance Plant. System was designed to provide 60,000 gph of properly conditioned water, free from hardness, scale forming minerals and corrisive gases. Graver Tank & Mfg. Co., Inc.

92 **Water Treatment**—Control of Fouling Organisms in Fresh and Salt Water, by John G. Dobson. Life history of these organisms; method of control. Wallace & Tiernan Products, Inc.

93 **Industrial Water Treatment**—Microbiological Control of and Through Industrial Waters; spot summaries of improvement of process efficiency and product quality of proper sterilization. Wallace and Tiernan Products, Inc.

94 **Cooling Water Treatment**—Bulletin 10 is an engineering information sheet on treatment of cooling water. A brief explanation of reaction in heat exchangers, condensers, etc., is presented. Bulletin describes necessary treatments. Liquid Conditioning Corp.

95 **Condenser Water Treatment**—Chlorination of Condenser Cooling Water, by R. B. Martin; important consideration in chemical treatment of cooling water circuits. Wallace & Tiernan Products, Inc.

96 **Clarifying and Softening Water**—Eight-page catalog "Reactivator for Clarifying and Softening Water by Upward Sludge Filtration." First part of the booklet tells how the reactivator works and how the sludge blanket is kept in control so as not to flow out with the clarified water. Line diagrams illustrate the principle of operation. Graver Tank & Mfg. Co., Inc.

97 **Feed Water Treatment**—This 4-page folder tells how the company's engineering applied to boiler feed water problems can result in savings. It tells of the different procedures and presents diagrams of equipment arrangement. Typical installations in dairy, cosmetic, aircraft, laundry, and other plants are pictured. Illinois Water Treatment Co.

98 **Chemical Feeding and Proportioning**—Bulletins 1100 and 1713A; use of adjustable chemical feeder for water treating, sewage, chemical processes, petroleum; plan and sectional diagrams; descriptions; photos; general specifications; 2-page table of capacity schedules; list of chemicals handled; accessories; drawings of boiler water conditioning systems; 5-page description of method of automatic intermittent feed of conditioning chemicals direct to the boilers; 20 pages. Proportioneers, Inc.

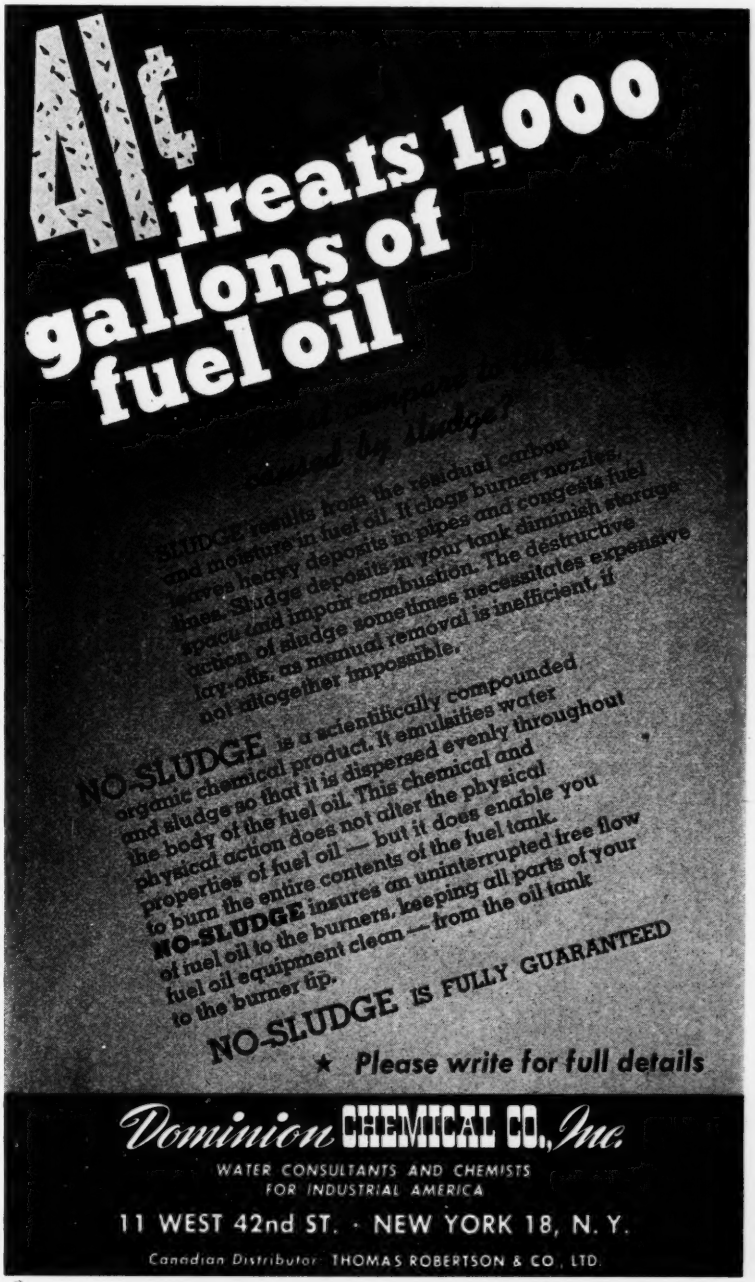
99 **Automatic Proportioning**—Bulletin 1200, 28 pages. Handy reference book containing wealth of information on automatic flow responsive equipment and methods in continuous process operation. Photos of equipment and installation are supplemented by many flow diagrams and detail drawings. Complicated subject made exceptionally clear and understandable by careful arrangement and two-color diagrams. Proportioneers, Inc.

100 **Water Conditioning Instruction Booklet**—Bulletin 28X6385 was written especially for guidance of power plant operators. It touches upon importance of feedwater control, care of test procedures. Handy reference tables given as aid to reporting results. Allis-Chalmers Mfg. Co.

101 **Complete Water Conditioning Service**—This 4-page bulletin describes this company's complete water conditioning service—analysis, design fabrication, installation and maintenance of water treating equipment. Typical installations are pictured and brief sketches of the men behind the service are given. Graver Tank & Mfg. Co., Inc.

COATINGS, TREATMENT

102 **Protective Coatings**—Four-page folder 844-246 describes Bitumastic Hi-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SLUDGE results from the residual carbon and moisture in fuel oil. It clogs burner nozzles, leaves heavy deposits in pipes and congests fuel lines. Sludge deposits in your tank diminish storage space and impair combustion. The destructive action of sludge sometimes necessitates expensive lay-offs, as manual removal is inefficient, if not altogether impossible.
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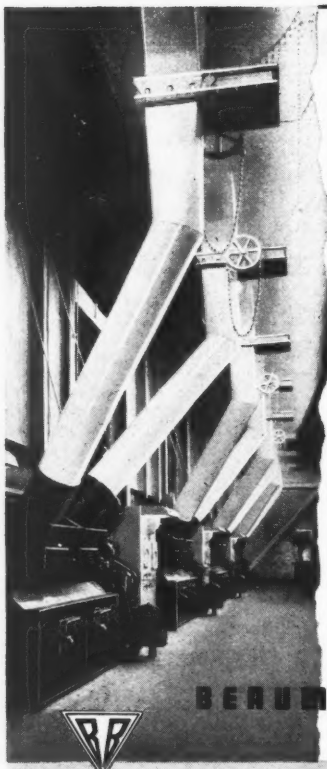

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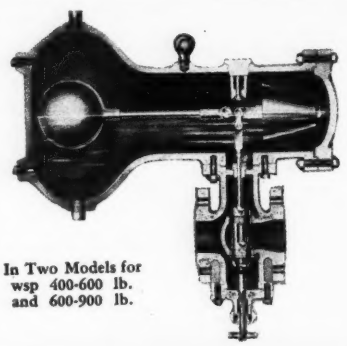

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Heat Gray, a specialized industrial protective coating which is said to resist corrosion and temperatures up to 1200 F. The folder is in two colors and contains several photographs of equipment on which Bitumastic has been applied. It also gives a list of uses for the material and a chart giving its characteristics. Walles Dove-Hermiston Corp.

103 **Flue Cleaner**—The company's soot and fire scale removing compound is described in this 6-page folder. Results obtained from the use of this compound are described in the first part of the folder and then a list of things which the company guarantees the material will accomplish are listed. Tables of dosage are presented and another table shows losses due to soot and fire scale. Dominion Chemical Co., Inc.

104 **Boiler Rust Treatment**—This 4-page bulletin describes the company's "Rustoff" chemical which is said to "build resistance to rust and scale corroded and congested pipes." The bulletin tells how the treatment works and what results may be expected from its use. A brief description of the company's service department is included. Dominion Chemical Co., Inc.

105 **Fuel Oil Treatment**—Several bulletins have recently been announced by this company describing completely the application and effect of its fuel oil treatment compound and Diesel engine solvents. Wilcolene Mfg. Co.

HEATING, COOLING

106 **Cooling, Heating, Air Conditioning**—Collection of bulletins; installation, design, construction data, capacity ranges, condensed physical data, numerous photos of installations, full page color diagrams of flow of air, compressed air, water, water spray, etc. Niagara Blower Co.

107 **Insulating Cement**—Ease of application, efficiency; ease of maintenance application recommendations; heat loss calculations, 4 pages. Baldwin Hill Co.

108 **Water-Cooled Stoker**—Catalog W; drawings of installations; features; furnace views; 8 pages. American Engineering Co.

109 **Spreader Stoker**—Installation views; features of various parts; cross-sectional view of furnace with installation; listed features; 8 pages. American Engineering Co.

INSULATION STOKERS

110 **Coal Reference Bulletin**—"600 Post-war Installations" of power plants in the United States are covered in Bulletin 10. Trend in new central stations and industrial plants is sketched and outstanding features of design of best stations described briefly. A table presents an industry classification of power plants by types of firing. Fairmont Coal Bureau.

111 **Pneumatic Spreader Stoker**—Three-fold booklet on the inner pages of which there are 30 spirally-bound vertical pages which fold back to tell the story of the stoker, installation, features, construction, principles, engineering, types and models, typical installations; well illustrated; 33 pages. Iron Fireman Mfg. Co.

112 **Poweram Stoker**—Bulletin 7121; essentials of successful stoker; fuel control, fuel convoying, fan capacity, controls, installation; illustrations; 18 pages. Iron Fireman Mfg. Co.

113 **Coal Reference Bulletin**—Bulletin 8, Underfeed Stoker Firing, Bulletin covers factors involved in selection of multiple retort stokers, principles, design data and drawings of typical installations; 6 pages. Fairmont Coal Bureau.

114 **Stoker Firing Operation**—Single Retort Underfeed Stoker Firing is the subject of Bulletin No. 9 issued by this Bureau. It is a complete analysis of the advantages of the single retort stoker in the smaller plants. Types of this stoker are described and principles of operation are outlined. Fairmont Coal Bureau.

OIL, GAS BURNERS

115 **Wide Range Oil Burning System**—Bulletin 109; how the system operates; control, drawings; 4 pages. Peabody Engineering Corp.

116 **Oil Burners**—Bulletin 108. Two types of oil burners, A and H; air registers, oil atomizers, drawings; 4 pages. Peabody Engineering Corp.

117 **Industrial Oil Burner**—New rotary fuel oil burner, designed for firing No. 6 or lighter oil, is described in Form 1160B. Illustrations of the units, lists of

specifications and a table of load capacities are given. Iron Fireman Mfg. Co.

118 **Oil Burner**—Wide-range Y-jet steam atomizing oil burner is described. Construction, application and advantages of unit are shown and bulletin tells how burner has established excellent standards of performance. The Babcock & Wilcox Co.

OIL, LUBRICATION

119 **Lubrication Recommendations**—Special oils for Diesels and heavy-duty gasoline engines; facts about oil; tables of recommended oils for various models; 18 pages. Standard Oil Company of California.

120 **Cutting Fluids**—Facts about cutting fluids, machine tool operations; fundamentals of cutting; how to apply; metallic cutting tools; tabular material; shop practices; 50 pages. Standard Oil Company of California.

121 **Diesel Operation**—Relation of fuels and lubricants to the operating efficiency of the diesel engine; diesel fundamentals; maintenance; lubrication and fuels; supercharging; selection and classification of fuels; fuel injection maintenance; improving cleanliness; tabular material, charts, formulas; 114 pages. The Texas Co.

122 **Engineers Report on Oil**—Engine tests, laboratory tests, effects on engines, bearing corrosion, actual service data, filter clogging, service experience; well illustrated with photos and charts; 42 pages. Standard Oil Company of California.

123 **Lubricants Service Handbook**—28 pages in this booklet on lubricants and their application. The development of the lubricant, its features and advantages and the manner in which it meets various operating conditions take up the fore part of the booklet. "Recommendations" section where the manufacturer tells just what grease or oil should be used according to speeds, temperatures, pressures and general service conditions is given. Fiske Brothers Refining Co.

124 **Oil Products for Industry**—Cutting oil, processing oils, general lubricants, refrigeration oils, Diesel oils, solvents, greases and waxes are among the petroleum products for industry which are described in this 4-page folder. The various grades of each oil are analyzed and the reasons why they are fitted to each particular job are given. Sun Oil Co.

POWER TRANSMISSION

125 **Speed Reduction, Increase Gear**—Bulletin S-130; description; gear cases; gear and pinion; bearings; lubrication; drawings and photos; 8 pages. The Terry Steam Turbine Co.

126 **Flexible Couplings**—Bulletin 57; two pages of drawings and tables of ratings for company's flexible couplings. Installations are shown and features of the various types are discussed; 20 pages. John Waldron Corp.

127 **Fluid Drives**—Bulletin 8019 tells about automatic fluid speed drives for 3600 rpm boiler feed pumps. Cutaway illustration and curve shows operational improvement and construction and operating features are pointed out. American Blower Corp.

VALVES

128 **Regulating Valve**—Bulletin 1-A; valve data book, description, dimensions and lists of parts; typical installations, rated capacities; prices; 52 pages. Atlas Valve Co.

129 **Pressure Reducing Valve**—Bulletin 1-C; sectional drawings, list prices, dimensions and weights; operation and adjustments; capacities for steam and air; 12 pages. Atlas Valve Co.

130 **General Service Valve**—Bulletin E-150; valves for blow-off; fire protection, soot blower lines, acids, process, etc.; description; exploded views; features; dimensions, weights and list price tables; parts and parts lists; 14 pages. Everlasting Valve Co.

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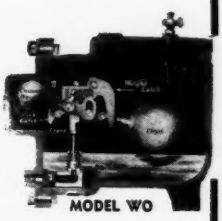
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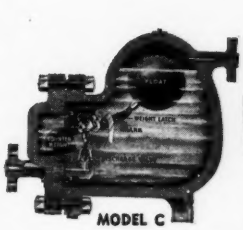
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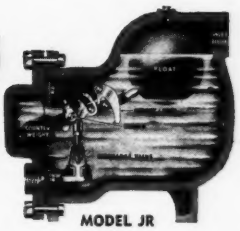
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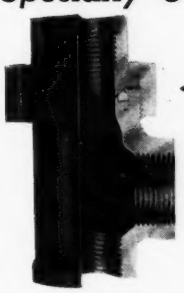

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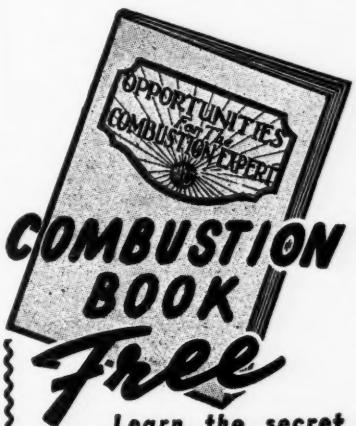

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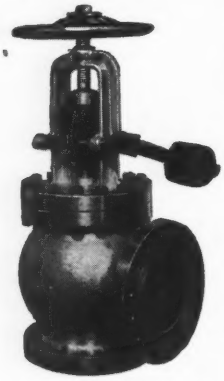

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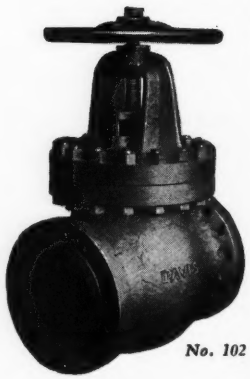

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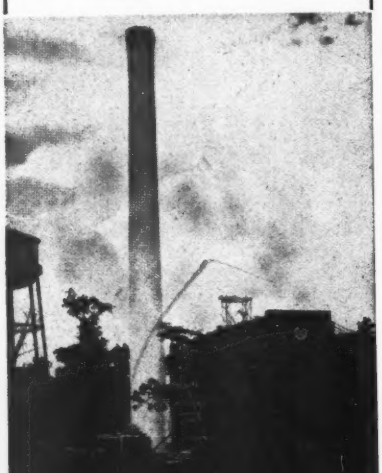

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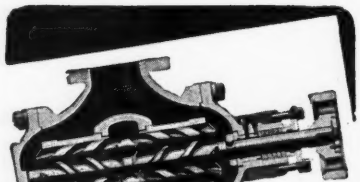

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134 **Control Valves**—Catalog 546 covers line of control valves for air, gas, oil, steam or water up to 500 psi. Applications are described and line drawings, detailed engineering information and material classifications are presented. W. H. Nicholson & Co.

135 **Air Release Valve**—Operation, construction and essential requirements of air release valves described in Bulletin 140. Discusses dangers of air in pipe lines and solution to problem. Simplex Valve & Meter Co.

136 **Self-Cleaning Strainers**—Bulletin 465 presents tables of screen specifications and total free hole area to facilitate correct screen selection. Tables of dimensions of cast iron, cast bronze, cast steel and stainless steel strainers. Charts, illustrations and photos complete bulletin. Leslie Co.

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137 **Maintenance Jobs**—This guide tells how better to perform commonly occurring power plant maintenance and cleaning operations. Illustrated manual gives specific material and method recommendations for handling cleaning, degreasing, descaling, derusting, paint stripping, etc. Booklet is completely indexed and reference is made by colored type strips on edge of the pages; 22 pages. Oakite Products, Inc.

138 **Condenser Tube Inserts**—Description of Flowrites; illustrated, accompanied by report of tests on Flowrites made by M.I.T. Tables and charts of test results are presented; description of how to install inserts given; 8 pages. Condenser Service & Engineering Co., Inc.

139 **Building Maintenance Guide**—"Over the Rough Spots," provides answers to more than 100 problems inherent in maintenance and construction of all types of buildings. Its 48 pages are packed with information about floors, walls, foundations, roofs, etc. Special information of interest to railroads, mines, utilities and water works. Stonhard Co.

CONTROLS, METERS

140 **Damper Regulators**—Bulletin 4-A; for low pressure heating, medium pressure power and high pressure power boilers; what they do; how to specify; typical installations (drawings); adjustments; list prices; technical descriptions and parts lists; 20 pages. Atlas Valve Co.

141 **Recording Flow Meter**—Bulletin 349; what it does, features, chart of rated capacity; construction and operation; installation drawings, tables of capacity; photos; 8 pages. Builders-Providence, Inc.

142 **Propeller-Type Meter**—Bulletin 350A; for main-line metering; applications, description, installation, materials of construction; features; table of capacity, shipping weights; specifications, drawings; 4 pages. Builders-Providence, Inc.

143 **Centralized Combustion Control**—Bulletin 43-605; application to various types fuels and burning equipment; controller, measuring elements, pilot device, power units, etc.; 24 pages. The Hays Corp.

144 **Combustion Meters**—Bulletin 44-550; reasons why it is accurate, dependable, simple, rugged, easy to install, easy to maintain, speedy, easy to understand; well illustrated by explanatory diagrams; 16 pages. The Hays Corp.

145 **Remote Feed Water Control**—Bulletin 471 describes Type P regulator for remote control of boiler feed water. Construction features of unit are described and complete hook-ups of the regulator with different types of valves are shown. Complete descriptions of hook-ups are given. Northern Equipment Co.

146 **Liquid Level Indicators**—Bulletin WG-1822, 16 pages, describes liquid level indicators for boilers, heaters and other vessels in industrial and central stations. Construction and operating details are covered. Installation instructions and specification information given. Yarnall-Waring Co.

147 **Electronic Instruments**—Bulletin 231 describes recently-developed line of electronic instruments for temperature, flow and other factors. Measuring circuits are described and diagrams presented;

these diagrams include resistance bridge, potentiometer circuits, impedance bridge and calculating circuits. Bailey Meter Co.

148 **Feed Water Regulation**—Bulletin 429B, 12 pages, covers the company's automatic flow regulator for controlling boiler feed water. Photos of installations, charts and studies of boiler water level control under various conditions of pressure and information on operation and construction of the unit are given. Specifications are listed. Northern Equipment Co.

149 **Engineering Monographs**—Series of eight on automatic combustion control: 1. How Close Can Steam Pressure Be controlled? 2. Why Operate Automatic Combustion Control from Changes in Steam Pressure? 3. Adapting to the Characteristics of Underfed Stokers. 4. Adapting to Spreader Type Stokers. 5. Adapting to Chain or Traveling Grate Stokers. 6. Adapting to the Characteristics of Pulverizers. 7. Adapting to the Characteristics of Oil Burners. 8. Adapting to the Characteristics of Gas Burners; total 37 pages. The Hays Corp.

150 **Draft**—Bulletin 46-472; what draft is; where it is found; how it is measured; what the draft gage tells, where to measure draft and pressure in steam plant; where to connect draft gages; how to install; drawings; 20 pages. The Hays Corp.

151 **Flue Gas Analyzer**—Bulletin 45-668; principle of operation; construction features; technique; models and prices; Burrettes—classification and uses (table); what flue gas analysis tells us; 16 pages. The Hays Corp.

152 **Indicating, Control Systems**—What they are, what they can do; Bulletin 14B6641. Description of how transmitter, receiver and indicator of systems are constructed, how they work, their advantages and specifications. Illustrated with photographs, diagrams, charts; 12 pages. Allis-Chalmers Mfg. Co.

153 **Water Gages**—Condensed catalog, Bulletin E, of company's complete line of water gages. Each model illustrated and accompanying table gives sizing information; 8 pages. Ernst Water Column & Gage Co.

154 **Stainless Steel Bellows**—Bulletin SSB-46; contains diagrammatic cross-section views and up-to-date information concerning the use of these bellows as equalizers, compensators, expansion joints, flexible connectors for flow control, vapor and steam traps, thermostatic instruments, etc. Completely illustrated; 12 pages. Chicago Metal Hose Corp.

155 **Pitot Equipment**—Three section Bulletin 50; gives complete details of the use of Pitot tubes and rods, instructions in the use of the company's portable Pitot recorder, together with theory, formulae, notations and curves. Completely indexed; 20 pages. Simplex Valve & Meter Co.

156 **Temperature Regulators**—Bulletin 7-A; six types; descriptions; list prices, tabular material, photos; list of parts; typical installation drawings; tables for finding sizes of control valves required to heat given quantity of water; 16 pages. Atlas Valve Co.

157 **Draft, Excess Air and CO_2**—Bulletin 39-341; discussion of the relation of these elements to the installation and servicing of bituminous and anthracite stokers by Arnold Soller; 12 pages. The Hays Corp.

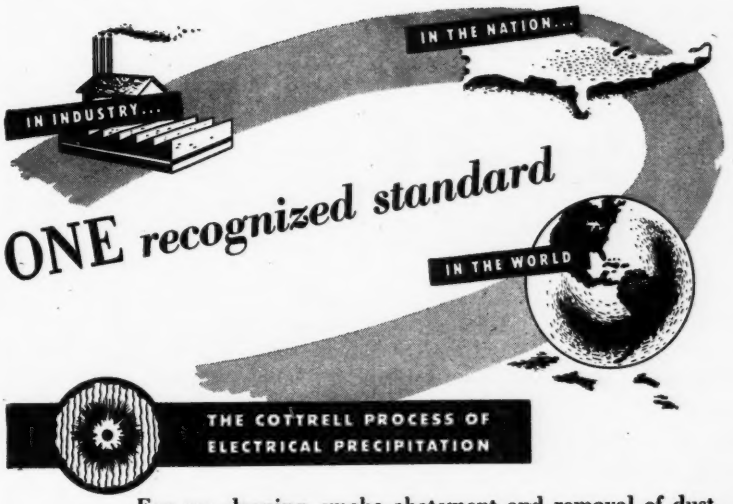
158 **Liquid Level Controllers**—Bulletin A-100 is a 4-page catalog describing this company's Types G and D liquid level regulators. Excellent cross-sectional views of the units are presented and their operational and constructional features are described. Dimensions, capacities and shipping weights are presented. Stets Company.

159 **Boiler Feed Control**—Bulletin 463, 16 pages, describes boiler feed control systems at Westover, Greenidge and Jennison Stations of N. Y. State Electric and Gas. Corp. Completely illustrated with photos and line drawings. Tables of significant data included, Northern Equipment Co.

160 **Water Level Control**—"Controlling Water Level on Combustion Engineering Type VU Boiler" is title of Bulletin 455. These four pages present photos and chart reproductions and tell the details of the company's control equipment on this particular type of boiler. Northern Equipment Co.

161 **Water Level Control**—Bulletin 459, 8 pages, description of water level control installation at Wyman-Gordon Co. Good illustrations show details of installation. Table of significant data given. Northern Equipment Co.

162 **Boiler Water Level Control**—Bulletin 467 and 465, 8 pages each, describe,



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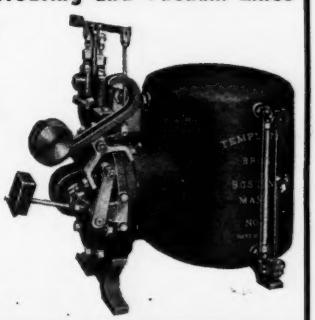

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167 **Welding Fittings**—Bulletin 47-1 covers stainless steel welding fittings . . . 90 deg elbows, 45 deg elbows, 180 deg returns, lap joint stub ends, tees, caps, reducers. Specifications for each type are presented and tables give complete dimensional data. Information on welding of stainless steel is given. Midwest Piping & Supply Co., Inc.

PUMPS

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172 **Centrifugal Pumps**—Booklet describes basic action of centrifugal pumps, tells of the science of centrifugal action and the physics of pumping. Performance curves are presented. Descriptions of the company's self-priming centrifugal pumps are given and how they operate is explained. Typical use of the units are pointed out and installation and operation explained; 20 pages. Marlow Pumps.

173 **Centrifugal Pumps**—Bulletin 240, 6-page folder describing single stage, double suction. Type DBL centrifugal pump. Features of the pump resulting from its construction and engineering; a sectional view which is used to point out other advantages of the unit. Tables of metal specifications and capacity ratings in gallons are also given. Warren Steam Pump Co., Inc.

174 **Multi-Stage Pumps**—Bulletin 241 describes 4 and 6 stage Type TM pumps. Cross-sectional illustrations and tables of specifications are given. Dimensioned drawings and tables of dimensions accompany copy describing unit's construction and advantages. Warren Steam Pump Co., Inc.

175 **Close-Coupled Pumps**—Close-coupled pumps, called Compac-units, are described in Bulletin 242. This 8-page bulletin presents clear and understandable cross-sectional photos of the units and uses these to point out construction and operation features. A full-page "Composite Rating Table" presents rating information at various heads for 9 different models of pumps. Warren Steam Pump Co., Inc.

176 **Compressors, Vacuum Pumps**—Bulletin C-5; 16 pages. Describes complete details of construction including illustrative material such as photographs of parts of the units and drawings of detailed structural parts. Tables present size and capacity information. Chart of typical characteristics is given. Fuller Co.

177 **Pedestal Type Pumps**—Listed in tabular form are heads and capacities of these units, also given is a Pump, Motor, Drive table. Operating advantages are listed and illustrated and features of construction are outlined. Allis-Chalmers Mfg. Co.

178 **Materials Handling Pump**—Catalog 547 describes all late developments in the "Hydroseal" pump. Line drawings and colored illustrations picture improvements in construction and tables show performance based on clear water. "Calculating the Pump Required," is a highly useful section of the bulletin. The Allen-Sherman-Hoff Co.

MISCELLANEOUS

179 **Floor Resurfacing**—This recently-published folder describes the methods of use of the company's heavy-duty resurfacer for use on floors, traffic aisles and loading platforms. It contains a concise, clear description of the properties, methods of application and advantages of the resurfacer and is of interest to everyone who has problems in the maintenance and repair of concrete floors. Stonhard Company.

180 **Electric Tools**—Bulletin 464; covers complete line of portable electric tools for construction and briefly describes such tools as electric hammers, drills, chisels, vibrating tools, accessories, screw drivers, etc. Prices are given. Syntron Co.

181 **Refractory Concrete**—"Lumnite for Refractory Concrete"; basic information on materials and methods used in making refractory concrete. Illustrations show application of concrete in construction of furnaces, coke ovens, etc. Lumnite Division, Universal Atlas Cement Co.

182 **Gas Purger for Refrigeration System**—Bulletin 160; tells how to cut power costs and raise condenser capacity by proper purging of non-condensible gases. Tables of ammonia properties, advantages, and complete illustrated material; 8 pages. Armstrong Machine Works.

183 **Grinding Wheels**—Grinding wheels of various abrasives are illustrated and list prices presented; tables of sizes in inches are accompanied by photographs and line drawings of these various wheels. Grinding wheel dressers with list prices are shown; 32 pages. Norton Co.

184 **Weldments**—Bulletin SP106 tells about the services of this company's weldry and the weldments turned out therein. The products of this weldry are shown and the text points out how flexible the method is. Graver Tank & Mfg. Co., Inc.

185 **Drop Forged Flanges**—Manufacturing processes; physical characteristics; full-page tables of illustrations, dimensions, weights and prices. Space provided for future insertions. Phoenix Mfg. Co.

186 **Vapor Cleaning Unit**—Latest equipment for steam detergent cleaning described in Form 6327R. Features of simple operation, control and delivery outlined by means of pictures. Engineering specifications and operating data given. Oakite Products, Inc.

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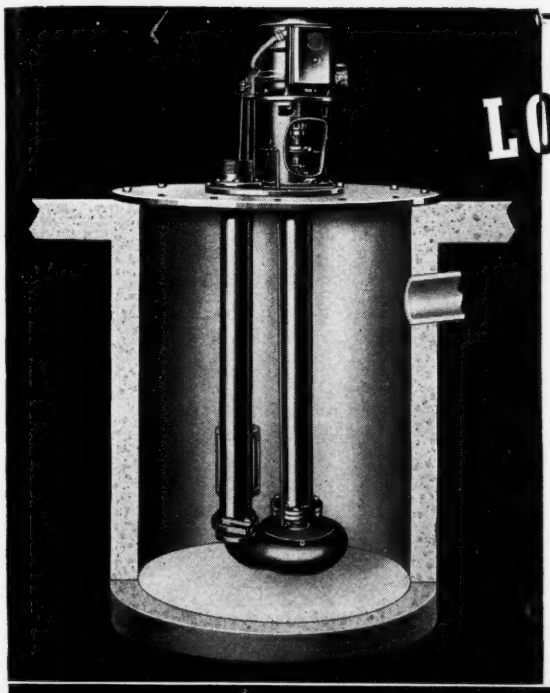
188 **High Side Floats**—Bulletin 178 describes inverted bucket high side floats for discharging liquid refrigerant to the low side of refrigerating systems. Five stages of operation are shown in drawings. Armstrong Machine Works.



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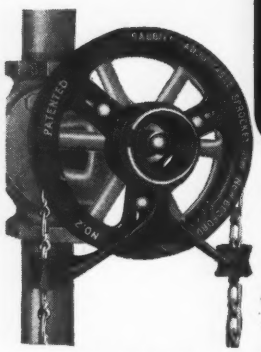

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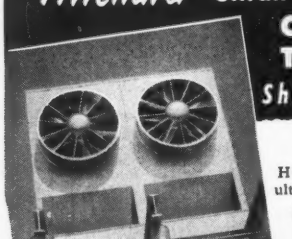

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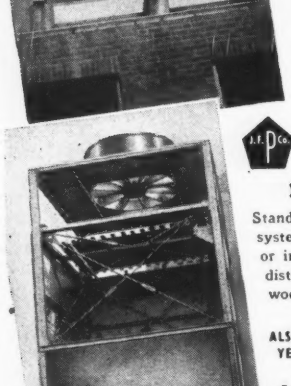

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POWER PLANT *Construction News*

Fla., Orlando—Orlando Utilities Commission has plans for expansion in municipal steam-electric generating station, with installation of equipment for increased capacity. Contract is being let for steel frame superstructure and work will begin soon. Robert & Co., Bona Allen Bldg., Atlanta, Ga., are consulting engineers.

Ga., Savannah—Union Bag & Paper Corp., Savannah, is reported planning further expansion in power plant and power facilities at local paper and paper board mill, with installation of steam-electric generating unit and auxiliary equipment. Cost estimated in excess of $2,500,000. Main offices are in Woolworth Bldg., New York, N. Y.

Ill., Chicago—Commonwealth Edison Co., 72 West Adams St., will begin work soon on proposed new power substation at 5043-49 West Madison St., to be known as Austin substation, about 42 x 86 ft. No estimate of cost announced. Holabird & Root, 180 North Wabash Ave., Chicago, are architects.

Kan., Coffeyville—Municipal Water & Light Dept., is considering expansion in municipal steam-electric generating station, including installation of equipment for increased capacity. Cost estimated about $825,000. Proposed to arrange bond issue in that amount.

Mich., Detroit—Burroughs Adding Machine Co., 6071 Second Ave., calculating machines and parts, has approved plans for new addition to boiler house at plant, estimated to cost about $100,000, with equipment. Construction will proceed at early date. Albert Kahn Associated Architects & Engineers, Inc., New Center Bldg., Detroit, is architect and engineer.

Mich., Escanaba—City Council, A. V. Aronson, city manager, has plans under way for new municipal steam-generating station. Proposed to carry out project in 1948. No official estimate of cost announced. Laramore & Douglass, Inc., 327 South LaSalle St., Chicago, Ill., is consulting engineer.

Minn., Minneapolis—Board of Regents, University of Minneapolis, plans extensions and improvements in power plant at institution used for central-heating service, with installation of new boiler and miscellaneous equipment. Cost reported close to $300,000. Helmick, Edeskuty & Lutz, Essex Bldg., Minneapolis, are consulting engineers.

Neb., Columbus—Consumers Public Power District, Columbus, plans new power substation on local site, reported to cost about $70,000, with transformers, switchgear and accessory equipment. Also will build power substations at Scottsbluff and Norfolk, Neb., each to cost about same amount.

N. Y., Niagara Falls—International Paper Co., 1225 Buffalo Ave., has preleminary plans for new steam power plant at local mill, reported to cost over $1,000,000, with boilers and auxiliary equipment. Main offices of company are at 220 East 42nd St., New York, N. Y.

N. C., Tarboro—Town Council plans extensions and improvements in municipal oil engine-operated power plant, including installation of new Diesel engine-generator unit and auxiliary equipment. Also will make extensions in municipal distribution system and facilities. Bond issue of $500,000, has been authorized for project.

N. C., Valdese—Waldensian Hosiery Mills, Inc., plans installation of electric power equipment in connection with an expansion and modernization program at knitting mill, including new addition to present structure. Proposed to begin work soon. Cost estimated about $725,000.

Ohio, Ashtabula—Cleveland Electric Illuminating Co., 75 Public Sq., Cleveland, Ohio, has preliminary plans for addition to high-tension switching station at Ashtabula, reported to cost close to $2,000,000, with transformers, switchgear and auxiliary equipment. A new power substation also is being considered at Fairport, Ohio, to cost approximately $850,000, with equipment and connecting lines.

Ore., Portland—Portland General Electric Co., 621 S. W. Alder St., is arranging an expansion and betterment program in 1948, including extensions in generating plants, power substations, transmission and distributing

lines, and other operating facilities. Fund of about $7,500,000 will be appropriated for project.

Tenn., Springfield—Springfield Utility Commission has plans under way for new motor-driven pumping station and filtration plant for municipal water system. Also elevated storage tank and tower. Entire project estimated to cost about $400,000. Proposed to carry out work in 1948. Howard K. Bell, Lexington, Ky., is consulting engineer.

Tennessee—Town Councils of Portland, Gallatin, Dickson and Springfield plan installation of municipal natural gas distribution systems, with joint pressure pipe line for main supply service, including meter houses, control stations and other operating facilities. Entire project is estimated to cost close to $2,000,000. Barnard & Burk, Triad Bldg., Baton Rouge, La., are consulting engineers.

Texas, Amarillo—Southwestern Public Service Co., Amarillo Div., plans expansion in local East steam-electric generating station, with installation of new 37,500-kw turbine-generator unit and auxiliary equipment. A new multi-story addition will be built to present building. Entire project estimated to cost over $5,000,000.

Texas, Corpus Christi—Central Power & Light Co., Corpus Christi, will expend about $18,000,000 in connection with proposed expansion and improvement program, recently referred to in these columns, including extensions in generating stations, power substations, transmission and distributing lines, and other facilities. Large increase in present generating capacity will be provided.

Texas, Dallas—Pure Ice & Cold Storage Co., 906 South Harwood St., has approved plans for new addition to cold storage plant, reported to cost over $85,000, with equipment. Proposed to begin work on superstructure at once. Bertram C. Hill, 4703 Ross Ave., Dallas, is architect.

Texas, Longview—Proposed new steam-electric power plant of Southwestern Gas & Electric Co., Shreveport, La., in vicinity of Longview, recently noted in these columns, will be equipped for a capacity of about 150,000-kw, and will represent a reported investment of approximately $10,000,000, including power substations, transmission lines and other operating facilities. Sargent & Lundy, 140 South Dearborn St., Chicago, Ill., are consulting engineers.

Utah, Provo—Department of Utilities, 7 South University Ave., has plans for expansion and improvements in municipal steam-electric generating station, with installation of new equipment for increased capacity. Cost estimated at $1,250,000. Bond issue in that amount has been authorized. Work will proceed soon. Elmer A. Jacob is engineer and superintendent.

Utah, Salt Lake City—Standard Oil Co. of California, 225 Bush St., San Francisco, Calif., plans power plant in connection with new oil refinery in vicinity of Salt Lake City, where large tract of land has been secured. Entire project is reported to cost approximately $5,000,000. Proposed to begin work early in 1948.

Wash., Friday Harbor—Orcas Power & Light Co., Eastsound, Wash., has plans for expansion in Diesel-electric generating station at Friday Harbor, including addition to present building and installation of two 300-kw Diesel engine-generating units and auxiliary equipment. Work will be carried out soon. W. S. McCrea, Perkins Bldg., Tacoma, Wash., is consulting engineer.

Wash., Tacoma—Board of Port Commissioners, George Osgood, manager, has plans for new four-story cold storage plant on water front, 130 x 156 ft, estimated to cost about $450,000, with equipment. Proposed to begin work soon. Smith & Murray, Perkins Bldg., Tacoma, are engineers.

Wis., Green Bay—Northern Paper Mills, Green Bay, has approved plans for new multi-story addition to power plant at mill, about 32 x 32 ft, and will install equipment for increased capacity. Erection will be carried out by day labor. No estimate of cost announced. Sargent & Lundy, 140 South Dearborn St., Chicago, Ill., are consulting engineers.

Wis., Holcombe—Northern States Power Co., Eau Claire, Wis., has tentative plans for new hydroelectric generating station on Chippewa River, near Holcombe, with ultimate capacity of about 35,000 kw. Project will include power dam, with 600-ft spillway section, generating station, power substation and transmission line to Jim Falls, about 15 mi. distant. Cost reported over $5,500,000.

Wis., Janesville—Wisconsin Power & Light Co., Madison, Wis., plans new power substation at Janesville. No estimate of cost announced. Proposed to carry out construction early in 1948.

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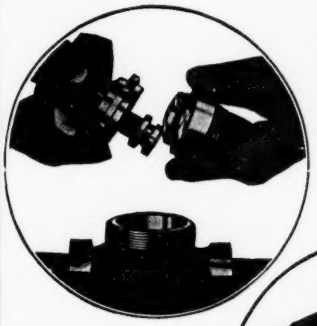

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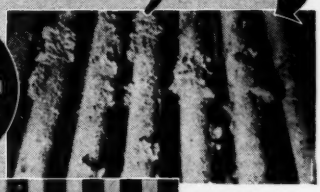

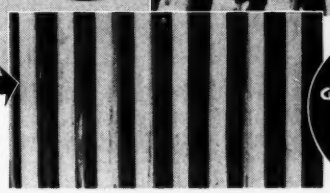

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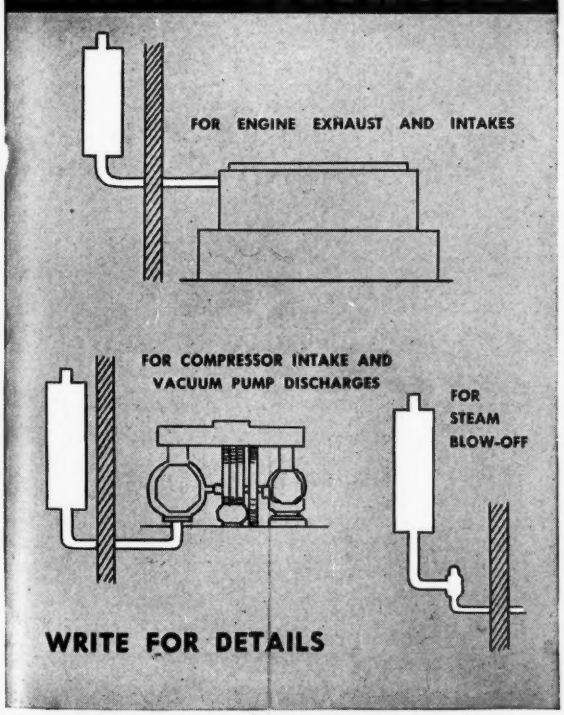

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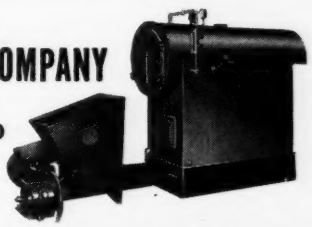

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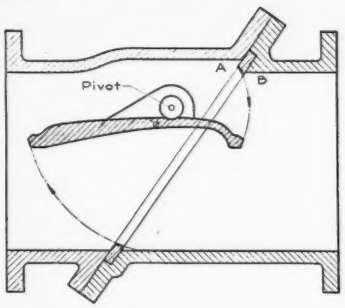


Cross-section of the Chapman Tilting Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

There's only *one moving part* in Chapman Tilting Disc Check Valves—the balanced hinge-pinned disc. When opened, the disc rides smoothly in the flow, minimizing wear on bearings and hinge pins. And since the disc seat lifts away when opening, and drops back when closing, there's minimum wearing of the seats. The disc closes quickly and quietly because of the effect of the stream against the short flap. Hammering and consequent strains on pipe lines are eliminated.

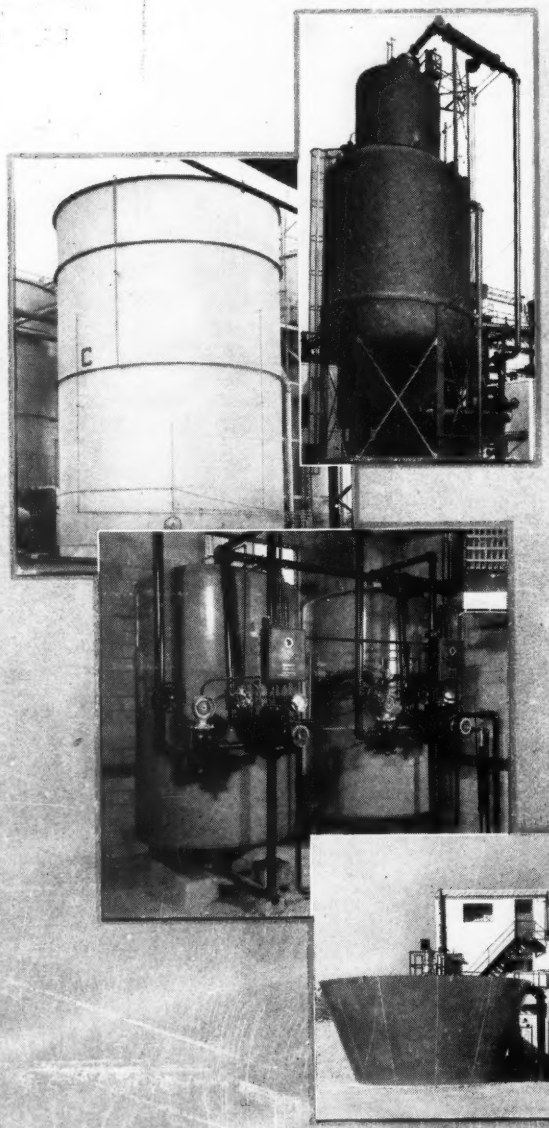
Head losses are also reduced to a minimum because of the design and balancing of the streamlined disc. Experience has proved that Chapman Tilting Disc Check Valves effect savings of from 65% to 80% in head losses over those experienced with conventional type check valves.

Chapman Tilting Disc Check Valves are available in either iron or steel.

Send for bulletin containing engineering data and reports of tests.

The Chapman Valve Manufacturing Co.
INDIAN ORCHARD, MASSACHUSETTS

Water engineered to any requirement!

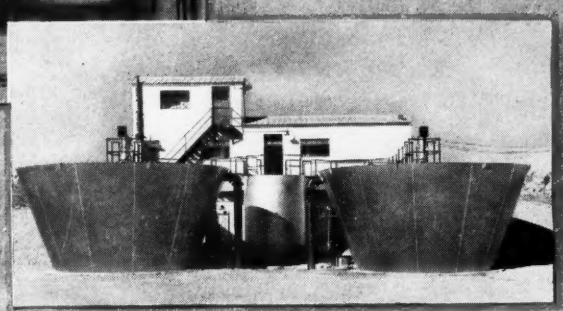


1. TO STOP CORROSION! Permutit's De-aerating heater prevents corrosion, removes all oxygen and free CO_2 from feedwater. Standard designs for pressure up to 100 psi and capacities up to 1,000,000 pounds per hour. Utilizes bled or exhaust steam.

2. TO ELIMINATE SILICA SCALE . . . by reducing the silica content with The Permutit Silica Removal Process! Reagents used are low-cost—do not add soluble byproducts. It can be adapted to existing equipment for hot or cold lime soda treatment or to Permutit Demineralizers.

3. TO SOFTEN WATER SUPPLIES! Permutit's Automatic Zeolite Water Softeners efficiently and economically remove hardness from water. The effluent is zero hardness water!

4. TO REMOVE IMPURITIES! Permutit's Precipitators remove turbidity, taste, color, odor, hardness, alkalinity, and other impurities from water supplies. Much less space, detention time and chemicals are required compared to conventional designs of reaction and settling tanks.



Write for full information on the equipment to The Permutit Company, Dept. PP-1, 330 West 42nd St., New York 18, N. Y. or to the Permutit Company of Canada, Ltd., Montreal.

Permutit

WATER CONDITIONING HEADQUARTERS FOR 34 YEARS